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QUARTERLY

OF THE

National Fire Protection Association

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40 CENTRAL STREET, BOSTON, MASS.

National Fire Protection Association.

INTERNATIONAL.

Executive Office, 40 Central Street, Boston, Mass., U. S. A.

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R. S. Moulton, *Assistant Secretary*

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Underwriters' Association of the Middle Department.
Underwriters' Bureau of Middle and Southern States.
Underwriters' Bureau of New England.
Underwriters' Laboratories.
Underwriters' Service Association.
Union, The.
Washington Surveying and Rating Bureau.
Western Actuarial Bureau (Fire).
Western Canada Fire Underwriters' Association.
Western Factory Insurance Association.
Western Insurance Bureau.
Western Sprinklered Risk Association.
West Virginia Fire Underwriters' Association
West Virginia Inspection Bureau.
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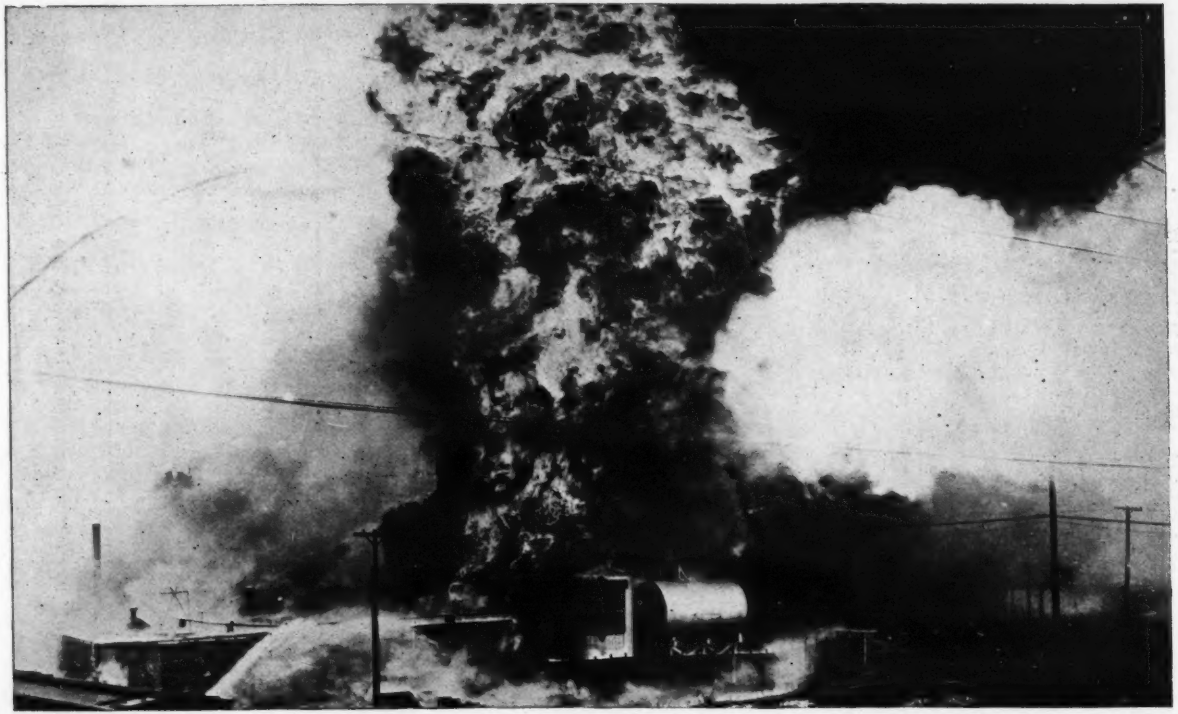
Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.



Wide World Photos

This St. Paul gasoline fire, which started when a tank car of casing-head gasoline was opened without proper precautions, cost two lives, four injuries and $90,000 damage. (See report on page 98.)

Anything which makes for progress must overcome resistance to new ideas.
—H. A. SMITH, *Chairman Insurance Advisory Committee, Chamber of Commerce, U. S. A.*

The Quarterly

Vol. 18 **July, 1924** **No. 1**

Twenty-eighth Annual Meeting. Atlantic City once more demonstrated that it is a good place to hold a working convention. The twenty-eighth annual meeting could not have successfully disposed of its heavy budget of business had local conditions not been well nigh perfect for a serious job. Never before in the Association's history had two evening sessions been necessary, and the attendance day and evening was so representative as to demonstrate once again that for the successful annual accomplishment of definite work the N. F. P. A. has no peer in the sisterhood of national organizations. The evening sessions abridged the opportunities for social intercourse it is true, and that was to be regretted, many members looking forward to our meetings as opportunities for making and renewing acquaintances with the leading men in our field; but it is reasonable to assume that this was an unusual year of heavy technical reports, and that next year in Chicago we shall not only have no evening sessions, but take our usual second afternoon for a visit to the Laboratories and have a little time to play besides.

* * * * *

The Field Secretary. With many members it is the hope and belief that this meeting marks an important milestone in the progress of the Association. While, as always when new projects are undertaken, some timidity was expressed in this case as to the wisdom of employing a field man before the normal growth of the Association made it possible to maintain such an employee out of current dues revenue, a very considerable majority believed such a step inevitable that the Association might continue to progress. An organization like ours, the success of whose object is dependent upon the local application of its technical and educational output, must finally stagnate if without means of following its principles into action. The activity of the field man must result in an increased membership, a membership whose dues

will finally furnish the fund to support this wider activity. Meanwhile there are generous members who are willing to see the matter through; who are real fire preventionists, willing to contribute to this cause as readily as they might to the support of a church, the Red Cross or an educational venture of any kind. In the event of some local disaster demanding relief, funds flow in from all parts of the country. Our present situation is the same except that it is relieved by representatives of the comparatively small body of men who are endowed with imagination to see the disasters that may occur, and move to avert them. Preventive measures in all fields of hazard are now recognized by the thoughtful as barometers of public intelligence.

* * * * *

The "Fire Chiefs Cabinet." "A fire chief can be a political fire chief or he can be a people's fire chief; but the kind of a bed he makes for himself he should be content to lie on," said Chief George L. Johnson of Waltham, Mass., in a clear, concise and logical speech at the June convention of the New England Association of Fire Chiefs. The subject of the "fire chiefs' cabinet" was under discussion and Chief Johnson said he had had one in Waltham for a dozen years without calling it that. "It doesn't matter what you call it," he said, "it is the idea I'm talking about."

No more convincing demonstration of the value of a non-political local group embodying the fire chiefs' cabinet idea could have been given than Chief Johnson's own experience. Political indifference had allowed the Waltham fire service to run down. The department was undermanned, the apparatus deficient, the fire houses incommodious, and the chief's appeals to successive mayors and councilmen awakened only a languid interest. After a fire which only by rare good luck and the unparalleled bravery and endurance of his best men had been extinguished before it reached conflagration proportions, Chief Johnson decided that he would either make his department worthy of the confidence his fellow citizens reposed in it, or give up his job and go fishing. He picked out half a dozen influential citizens of Waltham and told his whole story to them. They got together and discussed the matter. The city officials were called into conference. The department was motorized; the force was augmented, the fire houses remodeled, and the citizens who stood by Chief Johnson then are, with one or two additions, standing by him now. They are not elected, they have no official standing, they have no interest differing from the common interest. They merely know that they have a fire chief whose purpose is to make their city as safe from disaster as he can, and they are the boys to see that he has at least a fair show.

Politics and Fire Departments. "The conspicuous failure of the American Republic," wrote that great Englishman, James Bryce, "is the government of its large cities." It is not so easy in New York or Chicago to keep the fire department out of politics as it is in Waltham. Even civil service regulations inaugurated by a good mayor—and there are many good mayors—can easily be rendered inoperative by a bad one. There is no department of organized public service in which the result of political interference is so menacing to the common welfare as in the fire department. Chicago is just emerging from a period of fire department demoralization which was perhaps at its lowest at the time of the Burlington building conflagration three years ago. The spectacle of a fire chief wholly incompetent for his job and a fire commissioner whose interests would have been embarrassed by competence in his administrative officer was too disconcerting to encourage any sort of direct action by influential citizens of Chicago. They could not tackle the problem directly. They could only work to elect a new mayor. And meanwhile the men of the department—there are no better in any fire department in the world—and its officers of the fine type of John McDonnell and James Crapo were sweating blood and swallowing untold humiliation in the knowledge that the political adventurers who had the fire service in their clutches were rendering it incompetent to meet the test which a serious fire might at any time put upon it. The large city is in a class by itself; but this does not mean that some effective method may not yet be found to protect the morale of its fire department from destruction by selfish politicians. Could anyone be sure that the fire chiefs' cabinet idea would not work in a large city? Why should a large city fire commissioner not welcome the counsel and co-operation of such a group if he desires to give his best service? It might even be good politics for the man who had the imagination to see it.

* * * * *

The Matter of Salvage. The suggestion in the address of President Lacount that saving goods after a fire is just as important economically considered as saving them from fire itself, led to the appointment by the executives of the Committee on Salvaging Operations as reported in the July *News Letter*. While this may be a somewhat belated attack on this problem there is no doubt that the researches of this new committee into the best methods of salvaging various classes of goods and commodities will constitute a very real service to the public. As historically the first fire departments were organized and maintained by fire insurance companies, so also in somewhat later history, salvage corps were created and maintained. In a half-dozen American cities they are still so maintained although in all respects of service they are public

institutions. In these cities the corps turns out to every down-town alarm and spreads its tarpaulins over goods and otherwise looks after them with equal care whether the property is insured or not insured. Where the corps is officered, as in Cincinnati, by so capable and devoted a person as Captain Conway, the citizens generally derive a benefit from it far beyond the service for which it was originally organized. Captain Conway's connection with the Cincinnati fire department is organic and he has never spared his blood and toil in its service. It is obvious that the matter of salvaging is a proper function of the fire department itself, and one to be finally and completely assumed by it. In a number of cities the departments have for some time carried tarpaulins for spreading over goods especially liable to water damage. The recent organization in the Los Angeles department of a distinct salvaging section indicates the drift of opinion in the direction of the final assumption of responsibility for this function by the cities themselves.

* * * * *

The Waterworks Fraternity Emerges.

The organization in the American Waterworks Association (Member N. F. P. A.) of a fire protection division or section marks the emergence of that important and influential body from a static state that long puzzled the friends and admirers of the A. W. W. A. in the National Fire Protection Association. In the early years of the N. F. P. A. the A. W. W. A. was a member and was represented on our Executive Committee. Through reasons or influences never really understood it fell out of our councils, although many of our members interested in its co-operation stuck loyally to their membership in the A. W. W. A. The reawakening to the possibilities of its great contribution to the cause of fire prevention came to the American Water Works Association through the influence and enthusiasm of the Secretary of the Indianapolis Water Company, Frank C. Jordan, who is now the Association's president. The fine friendliness and big spirit of the retiring president, George W. Fuller, helped to awaken his association and put it in line for a full realization of Mr. Jordan's policies in fire protection work. These policies contemplate a larger action than the anticipated very valuable co-operation with the N. F. P. A. in matters of private water supplies from public mains. Mr. Jordan sees for the members of his association a new and larger public setting in their various communities as leaders in local fire prevention work. His own accomplishment in Indianapolis is a splendid illustration of the possibilities of this idea. The Indianapolis fire chiefs' cabinet, with Chief John J. O'Brien as its head, has had a wonderful friend and supporter of its policies in the local water company. With the fire prevention committee of the Indianapolis Chamber of Commerce and a picked group of influential citizens also

standing loyally by him, Chief O'Brien has wielded a power and influence second to that of no chief in the country; and the results in the betterment of conditions in his city show the efficacy of a non-political fire prevention group of this sort.

What Mr. Jordan has helped to do in his own city he now desires that the American Water Works Association should help to do in all the cities of the United States and Canada, and to this end is suggesting as a vehicle for stimulating such action a joint fire prevention committee of national organizations to take this work in hand. The Canadians, always quick to seize new ideas and courageous and enterprising in putting them into effect, recognized at once the possibilities of Mr. Jordan's plan. The Canadian Manufacturers' Association (Member N. F. P. A.) at its general annual convention in Montreal on June 3rd, unanimously adopted the following resolution:

> That the Officers of the Canadian Manufacturers' Association be requested to confer with the Officers of the National Fire Protection Association (International), the Canadian Section of the American Water Works Association (International), and the Dominion Association of Fire Chiefs, for the purpose of considering the creation of a joint Committee on Fire Protection; and, if in their judgment the participation of the Canadian Manufacturers' Association in the work of such a proposed joint Committee is desirable, that the President be authorized to appoint representatives of the Canadian Manufacturers' Association on such joint Committee when and if created.

The Canadian district of the A. W. W. A. is composed of unusually capable and energetic men and has as its present head the chief engineer of the Brantford, Ontario, Water Commission, Mr. Norman R. Wilson, who is well known to the underwriting as well as the engineering fraternity of Canada.

* * * * *

A Lesson from the Newspapers. Although the newspapers may be criticised for magnifying the importance of the personal and trivial, they usually sense the dramatic values and present them with a popular appeal which much formal fire prevention literature unfortunately lacks.

The New York Times under the headline "Surgeons Operate on Two Women on Roof of Burning Hospital," recently printed a dramatic account of a Brooklyn hospital fire. Quoting extracts from the newspaper's columns:

> Calm hands guided the knife despite the shouts of doctors, internes, nurses, and attendants who were removing 200 patients from the burning building.
>
> Firemen who answered the three alarms had the blaze under control before the flames could approach closer to the operating

theatre on the roof. Not a single patient was injured in the hurried moving.

A staff of nurses had the woman under the anaesthetic on the roof operating room. Life was at a low ebb. It was necessary, for the safety of the patient, to complete the operation. The surgeons and nurses kept a close watch on the fire, ready in a moment to fan away smoke that might irritate the patient's throat, or to remove her if the flames forced them.

No smoke entered the room. . . . They believed she would live.

The doctors had just completed this operation when they were notified that a patient on the fourth floor was about to give birth to a child. She was brought up to the operating room. . . . Neither mother nor infant suffered any ill effects from the fire.

Though this report may be criticised as overemphasizing the sensational, it draws public attention to the hazards of hospital fires in a most effective way. We were naturally interested in this fire and turned to our usual sources of fire record data for information, thinking that we might verify the facts and write a story which would be of some real use in promoting a fire-safe hospital construction. The report received from the inspector was as follows:

Tinsmith had been at work repairing metal roof for a few days and it is probable the heat of the soldering furnace passed through the metal roof and ignited the roof beams.

The fire was confined to roof and lath and plaster ceilings, front wall of mansard roof; front part of 4th floor St. Mark's Avenue side.

Damage by fire slight, but considerable by water.

The contrast between this and the story by the New York Times' reporter is so striking that it needs no comment. Those of us who are dealing with fires as a part of our everyday routine activities are all too apt to lose sight of their dramatic human interest and to think and speak of them in the prosaic language of the inspector. If in presenting our fire prevention recommendations to the public we could always emphasize the features of popular appeal, as the newspaper reporter aims to do, our message might receive more attention.

Meetings of Executive Committee.

May 12, 1924.

The usual session of the executives the night before the annual meeting was held at Atlantic City on the evening of May 12, 1924. The following members were present:

Albert T. Bell, Atlantic City, Chairman
W. F. Ballinger, Philadelphia
J. I. Banash, Chicago
Geo. W. Booth, New York
F. B. Quackenboss, Nashville
A. M. Schoen, Atlanta
C. L. Scofield, Montreal
W. F. Steffens, New York
H. V. Thayer, Boston
Louis Wiederhold, Jr., Philadelphia
H. O. Lacount, Boston, President
Rudolph P. Miller, New York, Vice-President
Dana Pierce, Chicago, Vice-President
W. E. Mallalieu, New York, Past-President
F. J. T. Stewart, New York, Past-President
Franklin H. Wentworth, Boston, Secretary-Treasurer

Business Transacted.

The report of the Chairman to the annual meeting was approved.

The report of the Treasurer was approved.

The Gas Products Association was elected to membership.

It was voted:

That the Association through the Secretary shall present the 1923 Edition of the National Electrical Code to the American Engineering Standards Committee for approval as American Standard. This is to be done by the N. F. P. A. acting as Sponsor for this Code under the Rules of Procedure of the A. E. S. C. under which rules a Sectional Committee, duly organized and approved under the rules, has voted approving the Code and its submission as above described. The vote is recorded as 35 affirmative, one member not voting out of a total membership of 36. The non-voting member is the representative of the International Brotherhood of Electrical Workers from whom no reply has been received to repeated communications.

It was further voted:

To advise the A. E. S. C. that the N. F. P. A. desires to reserve to itself the privilege under the rules to submit at a later date a revised personnel of the Sectional Committee by which the next revision of the Code shall be prepared and which shall either itself constitute the standing Electrical Committee of the N. F. P. A. or which shall co-operate directly and actively with such standing committee.

The Committee voted a special memorial of appreciation of the devoted service of F. J. T. Stewart, continuously a member of the Executive Committee since the year 1910 and for seven years its Chairman.

June 20, 1924.

The meeting of the executives following the annual meeting of the Association was held in New York City on June 20, for consideration of matters referred to the Committee by the Association, for revising the rosters of the various committees, and for consideration of reports, finances, communications, etc. The following members were present:

Albert T. Bell, Atlantic City, Chairman
George W. Booth, New York
William S. Boyd, Chicago
George W. Elliott, Philadelphia
Edward R. Hardy, New York
Samuel D. McComb, New York
C. L. Scofield, Montreal
W. F. Steffens, New York
H. V. Thayer, Boston
Louis Wiederhold, Jr., Philadelphia
Allen M. Schoen, Atlanta, Vice-President
Franklin H. Wentworth, Boston, Secretary-Treasurer

Business Transacted.

It was voted to hold the 29th annual meeting in Chicago, May 12, 13, 14, 1925, and a program committee was appointed consisting of the President, Secretary, Chairman of the Executive Committee, and Messrs. S. Boyd, J. S. Mahan and Benjamin Richards.

Messrs. William Emerson of Boston and Samuel D. McComb of New York were appointed to complete the Nominating Committee, 1925.

The following committee with authority to add to its number was appointed to investigate and report upon the subject of Salvaging Operations:

Edward R. Hardy (New York), Chairman
William G. Ball (Boston) J. J. Conway (Cincinnati)
Geo. W. Booth (New York) S. D. McComb (New York)
R. J. Scott (Los Angeles)

Items referred by Annual Meeting.

(a) The recommendation of the Committee on Manufacturing Risks and Special Hazards that no change be made at present in the requirements for foam protection in Regulations Governing Dip Tanks was approved.

(b) It was voted to approve on recommendation of the Committee on Blower Systems the following changes in the Regulations governing Blower and Exhaust Systems:

6 (f), third paragraph, change to read:
"The inlets of the suction ducts of the exhausters should be located at the different points of the rooms from which the vapors are to be removed."

9 (a) and 15 (a), following the first sentence, add:

"Wherever satisfactory metallic contact cannot be effected or maintained at joints or between different portions of the apparatus, so as to insure an uninterrupted electrical connection to 'ground,' copper bonds, properly and securely attached, shall be provided."

It was voted that the subject of Section M,—Underground Pipes and Fittings (outside protection), of the present regulations governing Automatic Sprinklers be transferred to the jurisdiction of the Committee on Field Practice.

A rule was adopted that the duration of technical committee chairmanships shall be limited to five years except on special action by the Executive Committee; that the members of such committees shall be appointed annually; and that not less than 20% of the membership of the same shall retire each year.

The officers were requested to consider favorably participation in the fire prevention efforts of the American Water Works Association and the Canadian Manufacturers' Association.

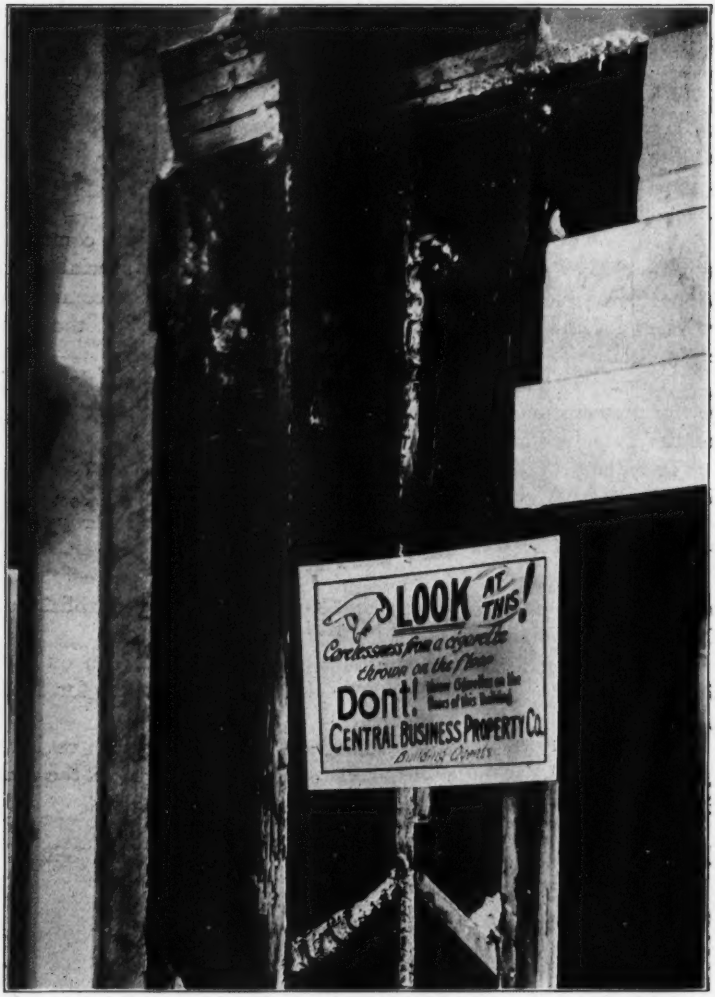
The plans of the officers for putting forward the work of the Field Secretary were discussed and approved.

The Budget for 1924-1925 submitted by the Treasurer was approved.

The Committee on Laws and Ordinances was requested to submit to the Association a suggested ordinance for the establishment of Fire Prevention Bureaus in local Fire Departments.

A suggestion for the preparation of a popular bulletin on First Aid Fire Appliances was referred to the Executive Office for favorable consideration.

The membership of the Association's Committees was reviewed in the light of the rulings above made and the changes in the same will appear in the forthcoming year book.



"Look At This!"

Chief A. L. Weeks of the Spokane Fire Department sends us this photograph taken after an office building fire, where the building manager has capitalized the lesson of the fire by posting this sign in the first floor hallway where all who enter the building pass it. The sign reads: "Look at this! Carelessness from a cigarette thrown on the floor. Don't throw cigarettes on the floors of this building."

The Wrong Incendiary.

By G. K. Chesterton.

In the field beyond the end of my garden the materials for a bonfire had been heaped; a hill of every kind of rubbish and refuse and things that nobody wants; broken chairs, dead trees, rags, shavings, newspapers, new religions in pamphlet form, reports of the Eugenic Congress and so on. All this refuse, material and mental, it was our purpose to purify and change to holy flame on the day when the King was crowned. The following is an account of the rather strange thing that really happened. I do not know whether it was any sort of symbol; but I narrate it just as it befell.

In the middle of the night I woke up slowly and listened to what I supposed to be the heavy crunching of a cart-wheel along a road of loose stones. Then it grew louder, and I thought somebody was shooting out cartloads of stones; then it seemed as if the shock was breaking big stones into pieces. Then I realized that under this sound there was also a strange, sleepy, almost inaudible roar; and that on top of it every now and then came pigmy pops like a battle of penny pistols. Then I knew what it was. I went to the window; and a great firelight flung across two meadows smote me where I stood. "Oh, my holy aunt," I thought, "they've mistaken the Coronation Day."

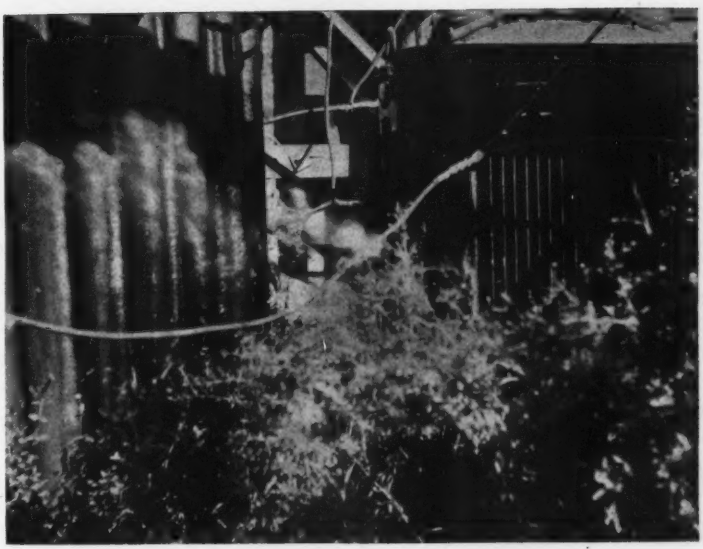
And yet when I eyed the transfigured scene it did not seem exactly like a bonfire or any ritual illumination. It was too chaotic, and too close to the houses of the town. All one side of a cottage was painted pink with the giant brush of flame; the next side, by contrast, was painted as black as tar. Along the front of this ran a blackening rim or rampart edged with a restless red ribbon that danced and doubled and devoured like a scarlet snake; and beyond it was nothing but a deathly fullness of light.

I put on some clothes and went down the road; all the dull or startling noises in that din of burning growing louder and louder as I walked. The heaviest sound was that of an incessant cracking and crunching, as if some giant with teeth of stone was breaking up the bones of the world. I had not yet come within sight of the real heart and habitat of the fire; but the strong red light, like an unnatural midnight sunset, powdered the greyest grass with gold and flushed the few tall trees up to the last fingers

of their foliage. Behind them the night was black and cavernous; and one could only trace faintly the ashen horizon beyond the dark and magic Wilton woods. As I went, a workman on a bicycle shot a rod past me; then staggered from his machine and shouted to me to tell him where the fire was. I answered that I was going to see, but thought it was the cottages by the wood-yard. He said, "My God!" and vanished.

A little further on I found grass and pavement soaking and flooded, and the red and yellow flames repainted in pools and puddles. Beyond were dim huddles of people and a small distant voice shouting out orders. The fire engines were at work. I went on among the red reflections, which seemed like subterranean fires; I had a singular sensation of being in a very important dream. Oddly enough, this was increased when I found that most of my friends and neighbors were entangled in the crowd. Only in dreams do we see familiar faces so vividly against a black background of midnight. I was glad to find (for the workman cyclist's sake) that the fire was not in the houses by the wood-yard, but in the wood-yard itself. There was no fear for human life, and the thing was seemingly accidental, though there were the usual ugly whispers about rivalry and revenge. But for all that I could not shake off my dream-drugged soul a swollen, tragic, portentous sort of sensation, that it all had something to do with the crowning of the English King and the glory and the end of England. It was not till I saw the puddles and the ashes in broad daylight next morning that I was fundamentally certain that my midnight adventure had not happened outside this world.

But I was more arrogant than the ancient Emperors Pharaoh or Nebuchadnezzar; for I attempted to interpret my own dream. The fire was feeding upon solid stacks of unused beech or pine, grey and white piles of virgin wood. It was an orgy of mere waste; thousands of good things were being killed before they had ever existed. Doors, tables, walking-sticks, wheelbarrows, wooden swords for boys, Dutch dolls for girls—I could hear the cry of each uncreated thing as it expired in the flames. And then I thought of that other noble tower of needless things that stood in the field beyond my garden, the bonfire, the mountain of vanities, that is meant for burning; and how it stood dark and lonely in the meadow, and the birds hopped on its corners and the dew touched and spangled its twigs. And I remembered that there are two kinds of fires, the bad fire and the good fire—the last must surely be the meaning of bonfire. And the paradox is that the good fire is made of bad things, of things that we do not want; but the bad fire is made of good things, of things that we do want; like all that wealth of wood that might have made dolls and chairs and tables, but was only making a hueless ash.



Defective Transformer Wiring.

The photograph above, contributed by Mr. A. N. Miner, Jr. (Member N. F. P. A.), is an excellent and striking example of faulty transformer wiring. We quote from Mr. Miner's letter as follows:

"While inspecting an electric light plant one of the employees told me of a peculiar condition existing at times at their outdoor substation, which he said would frequently sing and hum. I went out to the substation with him and found 13,200 volt transformers for lighting and power circuit on low concrete bases, surrounded by a wire fence. As I approached the transformers I saw that the wiring was very poorly installed and was close to the ground. Weeds had grown up around the wires. In kicking down some of the weeds, my foot felt as if it were asleep, and as I turned to take a picture of the 13,200 volt lines within a few feet of the ground, some of the weeds sprang back against the wire and short circuited, igniting insulation on the wire as shown in the photograph.

"Needless to say the electric light and power company immediately rewired the whole station. This is one of the most careless as well as unsafe installations that I have ever seen."

Hope Development School Fire.

By J. W. Stevens (Member N. F. P. A.)
Fire Marshal, State of California.

On the evening of May 31, 1924, about 8:45 P. M., fire was discovered in the Hope Development School, at Playa Del Rey, near Venice, California. As the result of this fire the matron and twenty-three of the forty-one girls at the school lost their lives. The matron, Mrs. J. C. Thomas, gave her life attempting to save her wards. All of those rescued were led or carried to safety by the assistant matron. This was a privately operated school for subnormal girls, although county wards were inmates at the time.

As is customary, the public in this particular section of the country is greatly excited and demanding that steps be taken immediately to prevent a re-occurrence of the tragic affair in some similar institution. It is hoped that some definite action will be taken before public sentiment wanes.

One of the girls confined at the home has made a statement admitting that she started the fire for the purpose of getting away from the place. This may or may not be true in view of the mental condition of the girl.

Previous to the time of the fire all of those in the building, except the assistant matron who was reading in her room upstairs, had retired, and the fire was discovered simultaneously from the outside by a disabled soldier who was a camper on the beach, and the attendant at an oil station across the street. The soldier drove to the building in his machine, gave the alarm with a police whistle, and attempted to rescue the inmates, but because of the speed with which the fire spread this was impossible, so he drove to fire headquarters, which is the nearest fire station, about two and one-half miles away, to give the alarm. In doing this he passed five fire alarm boxes, one of which is within two blocks of the school building. This building was of frame construction, about 60 by 80 feet, two stories with small basement which opened out on the beach, and was built about twenty-four years ago. It was originally planned for a hotel, but had been vacant for many years. About three years ago it was leased and the lessor established the school. The proprietor of the school was absent at the time searching for a safe place to house the girls. Housing conditions in Southern California played their part in the tragedy.

Fire Chief Geo. A. Hubbard, of Venice, had inspected the place from time to time, realized the danger, and while he had no authority to condemn it, had personally taken fire extinguishers into the building placing them on the walls.

The usual reports about the inmates, girls ranging in age from five to twenty-five, being locked in their rooms and strapped into their beds, were circulated. These reports have not been verified. The investigation disclosed the fact that in most cases the girls had not left their beds, this being shown by the uncharred portion of their clothing on their backs which had been protected by the bed.

On the arrival of the first fire company the men found the entire building enveloped in flames and by the time they had taken suction the northeast and south walls, as well as the roof, were falling in. Two fire engine companies worked at the fire with four lines of 2½ inch hose. The lives had been lost and the building destroyed before the arrival of the fire department. As soon as the burning ruins had cooled off so as to permit doing so, search was started for the bodies. The firemen knew there would be loss of life when they left their stations to answer this call.

There is nothing unusual about this fire. On the contrary this is just the kind of thing that is expected to happen where people are housed in numbers in that type of building and under such conditions.

The California state fire marshal law does not give authority to condemn buildings of this type used for such purposes. It is the hope of the fire chiefs of the state who sponsored the law a year ago that this may be taken care of when the Legislature convenes next January.

The Story of Salem, Massachusetts.

By C. P. Faunce and H. C. Annable.
(Members N. F. P. A.)

Ten years ago, one third of Salem lay waste, gaunt chimneys standing sentinel over smoking cellar holes, one third of the city homeless, thousands sheltered under tents, military rule plainly in evidence, emergency relief pouring in from all quarters.

Fire started in a frame leather factory in highly flammable material the use of which should have been allowed only under strictest regulation or forbidden altogether. The few firemen responding on the first alarm had trouble at the hydrant, and before they could get water a brisk gale had blown burning embers to scores of wooden shingle roofs. While apparatus was responding on general alarm and before nearby householders could realize the impending danger, an uncontrollable conflagration was on.

The population of the city was then, and is now, approximately 45,000. The industries directly involved in the fire were leather, shoe and cotton manufacturing, carried on in buildings varying from the frame unsprinklered fire trap in which the conflagration started to a brick sprinklered mill with all modern fire appliances which finally succumbed before the irresistible heat of acres of burning tinder boxes. Detached dwellings in large districts which would have been pronounced immune, went down in common catastrophe with frame tenement houses crowded together and long recognized as a fire menace. In addition to direct loss of life, which fortunately was small, there was another result not often mentioned as the result of such a fire, the shattered health of many from fright, from exposure and from over-exertion.

So came, on a hot dry day, the bitter fruitage of improper construction, inefficient fire department, inadequate water supply and other ill conditions which are the common (and unnecessary) lot of the average American city.

The first shock of the disaster over, emergency rations and shelter provided, Salem set about looking the future in the face. War conditions were a serious handicap and materially delayed reconstruction. But now, as the result of the survey preceding the application of the insurance rating schedule which charges for all deficiencies in the many details recognized as affecting the fire hazard, we find only half a dozen New England cities in as high a grading class as Salem, none in a higher.

How has this come about? The following summary will give a fair idea of how this has been accomplished.

The Rebuilding Commission.

Immediately following the conflagration, by special act of the Massachusetts Legislature, the Governor appointed a Rebuilding Commission of five to serve for three years. During this term all rebuilding operations were under the control of the Commission which included in its authority the difficult task of making regulations which should not be prohibitory but which should result in safe reconstruction. The plan in brief was to allow frame dwelling houses not more than two and one-half stories in height, to be occupied by not more than two families and to be built at least five feet from side lines of the lot. Otherwise brick or similar construction was required. In all cases substantial roof covering such as slate, asbestos or metal must be used. At the same time, applying to the old sections, the city government passed revised building laws which in many respects duplicated the requirements of the Rebuilding Commission for the burned district. One result was that immediately throughout the city the wooden roof shingle became an outlaw and has so remained; if a person wishes to patch his wooden roof he must do it with non-combustible material. Probably not more than ten per cent of the entire roof area of the city is now covered with wooden shingles and these must soon wear out and be replaced by standard covering. The wooden three-decker has also remained outlawed both in and out of the burned district.

The Water Supply.

The most expensive and valuable improvement has been in the water supply. A new 10,000,000 gallon reservoir has been constructed, and the average hydrant pressure throughout the city increased from 46 to 82 lbs., the maximum pressure from 55 to 87 lbs., and the minimum from 12 to 44 lbs. This reservoir connects by a 36 inch feed main with the distributing mains radiating from the center of the city. Of the old feed mains, the smaller entered the city over piling which was not approved as absolutely secure, the other over a bridge exposed to possible breakage. While both the old feed mains are retained, the new one reaches the city beneath the river bottom and is nowhere exposed to breakage under any ordinary conditions. Old horizontal compound duplex steam pumps with rated capacity of 5,000,000 gallons each were replaced by two steam turbine units of 10,000,000 gallons per day each and other improvements have been made at the pumping station.

Miles of old cement lined ~~wooden~~ sheet iron pipe have been replaced by cast iron mains of greater diameter; for example, the feed to one district was through half a mile of 6 inch cement lined ~~wooden pipe~~ sheet iron pipe which was re-

Construction before the Salem conflagration. Wooden "three-deckers" and in the background a four-story tenement, all of wood and crowded together, illustrating common construction as found before the fire in that part of the burned district known as the "Point."

placed by 16 inch cast iron. No cement lined ~~wooden~~ sheet iron street mains remain except that in a few cases for possible emergency they remain parallel to the new and larger pipes. Hydrants were prior to the fire largely of the Lowry flush type, only 34 post hydrants being set prior to 1914. In connection with new piping, 358 post hydrants were installed and 217 of the flush type removed.

While to cover every possible chance pumping engines respond on first alarm and it is the practice to use them at fires of any size, the hydrant service alone will deliver 24 standard fire streams in nearly all parts of the city. At the lower pressure necessary for engine feed, the

This is in the heart of the rebuilt "Point" district. The brick building at the left houses sixteen families; the sections are divided by brick fire walls as required. The two-story dwelling in the rear has non-combustible roof covering, chimneys are of brick with flue lining, all wooden partitions are fire-stopped at each floor, and because of frame construction the house may be occupied by not more than two families.

system will produce sufficient flow to supply 30 pumpers of average capacity with all the water crews can handle.

Fire Department.

The changes have been in effectiveness, not in size. There are in number no more companies, no more fire stations, than ten years ago. While the full paid men, including officers, were increased from 19 in 1907 to 59 in 1924, the number of call men has been reduced from 80 to 35. At the time of the conflagration there was only one piece of motor

driven apparatus. The department has now been completely motorized. At the start of the conflagration which was during meal hours of all companies, seven full paid men responded of which five were drivers of horse drawn apparatus and therefore not available for fire duty. The general alarm brought only two more full paid men.

Ten years ago there was no regular or systematic plan of drills or training. Regular drills involving both individuals and entire companies are now a part of the routine. Systematic and effective inspections of mercantile and public buildings are a part of the regular service of the department.

During the conflagration the fire alarm system did not fail, being more nearly up to standard than any other sections of the city fire service. There have been various minor improvements, however, such as completing protection from exposures to headquarters by means of wired glass windows; installation of lightning arresters between overhead and underground circuits, etc.

There have been many minor improvements in every direction. Formerly the fire department was not notified when a street was closed; this is now properly regulated by city ordinance. The national standard hose coupling thread has been adopted. Various small appliances have been added to the fire apparatus equipment. Two old fire stations have been repaired and the main defects overcome. Standard records are now kept. The department is equipped with 3 inch hose according to modern practice. Foam extinguishers are now carried on all apparatus. As late as 1922 it was reported that "the police do not co-operate with the building department"; this condition is now satisfactory. Water department records have been brought up to standard. As one man expressed it, "slack ends have been taken up."

These many changes, of varying degrees of importance but all essential to the final result, have been brought about indirectly by public sentiment and by the influence of organizations like the Chamber of Commerce; and directly by successive administrations of the City Government, no one of which has failed to do its part in its turn.

What Salem has accomplished under difficult conditions, furnishes an interesting example of the possibilities of improving the fire defences of a city of this size, an example which might well be followed by other communities that have not had Salem's conflagration experience.

Fumigation of Flour Mills and Elevators.

By Eugene Arms.
(Member N. F. P. A.)

The problem of the proper fumigation of flour mills and grain elevators has always been an important one. Various methods have been developed which perform this function satisfactorily, but some methods which are most efficient from the viewpoint of fumigation alone, involve serious fire hazards.

The extermination of insects in flour mills and grain elevator properties is more difficult than in most industries, for the reason that the insects are, during the period of development, protected by a mass of grain or flour, and the adults, except for the moth types, remain within the stock.

Different methods of fumigation must be used to exterminate the various insects. The Grain Weevil and Angoumois Grain Moth with larvae embedded in the kernel respond to one treatment, while the Yellow Meal Worm, the Black Carpet Beetle, the Cadelle, the Confused Flour Beetle and the Saw-toothed Grain Beetle require different treatment. The Mediterranean Flour Moth requires still another method of treatment.

Methods of fumigation or sterilization by heat have been developed which are fairly effective for each of the conditions but one of the most efficient methods of killing the Grain Weevil and Angoumois Grain Moth, from the standpoint of fumigation alone, introduces a very serious fire and explosion hazard. Carbon bisulphide, whether sold as such or disguised under a trade name, is exceedingly explosive, very much more so than gasoline. Its fumes ignite and explode spontaneously at comparatively low temperatures.

Nearly every mill is regularly fumigated or sterilized, usually twice each year, and the importance of encouraging reasonably safe methods and prohibiting dangerous methods is readily recognized.

Species of Insects.

There are more than seventy species of insects in the United States which are listed as destructive to grain and grain products. Those most commonly known and most destructive are as follows:

YELLOW MEAL WORM. The larva is cylindrical, long, slender, more than one inch long when fully grown, waxlike in appearance. It resembles a wireworm. The adult is more than half an inch long, of beetle shape, shining and nearly black.

CONFUSED FLOUR BEETLE. The larvae are little white worms, about one-fourth of an inch long. The beetles are about one-sixth of an inch long, dark brown in color. These are the most common of the flour beetles.

SAW TOOTHED GRAIN BEETLE. The larva is a slender, yellowish white and very active worm. The beetle is about one-tenth of an inch in length, slender, flattened and dark brown in color.

CADELLE. The larva is about three-fourths of an inch in length, with dark brown head and tail. The tail is split, ending in two horny points. The body is whitish and somewhat hairy. The beetle is black and about one-third of an inch long. The body and thorax are loosely joined.

BLACK CARPET BEETLE. The larva is brown, about three-fourths of an inch in length, tapering toward the tail which ends in a brush of long hairs. The beetle is about one-eighth of an inch long, is oval and black.

GRAIN WEEVIL. The larva is a small maggot-like worm which works inside the kernel. The adult is a cylindrical beetle about one-sixth of an inch in length and with head prolonged into a snout. It is from shining chestnut brown to nearly black in color, and is very firm and hard.

ANGOUMOIS GRAIN MOTH. The larva is of the common moth caterpillar type, one-fifth of an inch long, white with a yellowish head and six legs. It develops within the kernel. The adult is a small light grayish brown moth, measuring across the extended wings a little over half an inch, with wings narrow, pointed and bordered with long fringe.

MEDITERRANEAN FLOUR MOTH. The caterpillar is whitish or pinkish, slightly hairy and about one-fourth inch in length. It spins tubes in the flour, causing it to become matted. The adult moth is less than an inch across the extended wings and is a slightly mottled dull gray.

Importance of Cleanliness.

The first consideration should be given to the construction of the mill or the grain or flour storage. Buildings should be so constructed as to avoid damp dark places. Floors and walls should be joined so that accumulations along the edges and in the corners can be easily swept out. Floors of all basements should be concrete. There should be no concealed spaces, such as frame buildings sheathed on the inside, or in partitions with sheathing on both sides of the studding. All wood work should present a smooth surface and should be painted to close all cracks between boards.

The usual type of old building can be very much improved along these lines by eliminating concealed spaces under bins, dead ends on conveyors, unused spaces in bottom of conveyors, and inside sheathing, and by using paint liberally.

All machinery that does not rest directly on the floor without concealed space underneath, should be placed high enough to permit of thorough cleaning and brushing beneath. The bottoms of stock conveyors should be rounded to such an angle that the static stock in the conveyor will be reduced to the minimum. The hoppers of rolls should be constructed in such a manner as to allow no flour to accumulate in inaccessible places. Brushes are recommended on elevator leg belts to clean the interior of the elevator legs.

Until these breeding places are eliminated no method of fumigation will be found entirely satisfactory.

The object of the above methods of construction is to promote cleanliness, but the object will be defeated if cleanliness is not then practiced. Dust or spilled stock should not be allowed to accumulate. Scrupulous cleanliness will eliminate to a very large extent the necessity for frequent fumigation.

Flour and Meal Sterilization.

Manufactured stocks are not generally assumed to be subject to fumigation. The fumes do not sufficiently penetrate the stock. Infected flour or meal should first be resifted through as fine a cloth as the stock will pass through. This removes all of the adults and larvae, but will not eliminate all types of eggs. It would seem that there is only one method of killing the eggs absolutely, and that is by heat. Special machinery must be employed in the process, with steam usually acting as the heating agent. By the efficient application of this method the worst infected flour may be very effectively sterilized.

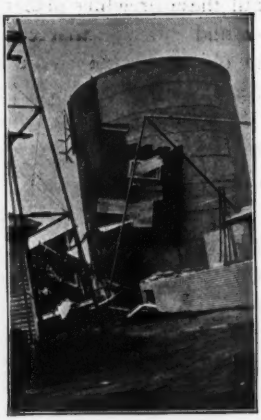
Carbon Bisulphide Fumigation.

Carbon bisulphide is several times heavier than air and quickly flows to the bottom of a bin of grain, displacing the air. It is very toxic and for this reason it would be a very efficient fumigant for use in storage grains were it not for the fact that it is extremely explosive and is, therefore, too hazardous for general use.

Many cases are on record of fumigation with bisulphide of carbon being the cause of explosions resulting in large property damage and some loss of life.

The accompanying photographs of the wreckage of the Hurlock Milling Co., Hurlock, Maryland, illustrate the effect of a carbon bisulphide explosion. Two buckets of the liquid had been poured into the top of the steel tank which communicated to the elevator by a passageway. A few minutes later the owner attempted to tighten some loose bolts on the tank with a hammer. The explosion followed immediately after the blow of the hammer, and it is assumed that the hammer blow ignited the gas. One man was killed and others injured.

Carbon bisulphide gas ignites at a very low temperature. A case was recently reported from Kansas of some weevil-infected wheat being placed in a bin in a room with a gasoline engine. The engine was permitted to cool for three-quarters of an hour, at which time it was thought that there was no possible chance of danger. The exhaust pipe of the engine was still sufficiently hot to explode the gas, and the operator was



Two views of the wreckage from an explosion of carbon bisulphide vapor. A spark from a hammer blow ignited the vapor from two buckets of the liquid which had just been poured into the elevator for fumigating purposes.

badly burned. It does not take a flame or spark, or even a very hot surface to ignite the carbon bisulphide gas.

The product comes clearly within the classification of explosives in the standard fire insurance policy, and its use invalidates the contract. Nearly all insurance companies specifically prohibit its use and many of the railroads have prohibited its use for the fumigation of grain in cars. There are many fumigants on the market under trade names which use carbon bisulphide as a base. These should be classed with it in every way.

Hydrocyanic Acid Gas Fumigation.

The hydrocyanic acid gas method is effective against all kinds of insects except those that are inaccessible to the fumes by reason of their location, such as weevil or beetles in grain or flour. This is the gas that is being used for execution of criminals in one state, and the inhalation of even a small amount of the gas is almost certain to be fatal. Therefore, it should never be used except under the supervision of someone who is fully conversant with its properties.

The mill must be specially prepared to make this method efficient. Before closing down the mill the feed should be stopped and all machines allowed to empty. The machines should then be cleaned and brushed out, removing all accumulations of stock or dust, and left open. The entire plant should be cleaned as thoroughly as possible, and the cleanings re-

moved and disposed of in such a manner as not to be brought back into the mill.

The buildings must be made as nearly air tight as possible, pasting paper over or packing such cracks as cannot otherwise be closed. Each floor should be made entirely separate from the other floors. All belt holes should be stuffed with sacks and all elevator shafts closed.

To provide for ventilation after the fumigation, two opposite windows on each floor should be so arranged that they may be opened from the outside from a distance of a few feet. Danger signs indicating fumigation should be placed on all sides of the mill, and a watchman should be on duty to guard the mill during fumigation.

The necessary equipment consists of sodium cyanide, sulphuric acid, water, stone jars (four-gallon size), paper sacks (common manila, size Nos. 8 or 10, such as may be obtained from any grocer), and vessels for measuring and carrying the acid and water (one-gallon or two-gallon graniteware cups or pitchers are most convenient; tin vessels must not be used).

The formula for production of the gas is sodium cyanide 3 pounds, sulphuric acid 4½ pints, and water 9 pints. If the property is well constructed and reasonably tight, one pound of sodium cyanide is sufficient for each 1000 cubic feet in basement, 1200 cubic feet on first floor, 1400 cubic feet on second floor, 1600 cubic feet on third floor, and a proportionately larger amount for each successive floor. If the floors cannot be handled separately the amount should be increased on the lower floors and decreased on the upper floors, because the gas is lighter than air and rises.

The method of procedure is as follows: Measure into each jar the proper amount of water and distribute the jars so as to afford easy access to them in rows upon each floor of the building. Avoid placing them alongside of any belt, sacked material or anything that might be injured from spattering or leakage from the occasional cracking of a jar.

Measure out the acid and add it to the water in the jars. Always pour the acid into the water, not water into acid.

After the jars have been arranged and the acid added, the cyanide should be broken into small lumps, none of which should be larger than a hen's egg, and made up into three-pound packages in the double manila sacks; that is, one sack placed inside the other.

The cyanide should be handled with leather gloves, and out in the open air where the operator may avoid inhaling the dust. Care should be taken to avoid any particles flying in the eyes or mouth. It is well to protect the eyes with goggles. A bag containing cyanide should be left at

the side of each jar. Before dropping the bags of cyanide into the jars, an inspection of the entire building should be made to see that all windows are closed and everything ready and in its place so that after the first jar has received its cyanide it will be unnecessary to stop to adjust anything. The operator should begin on the upper floor of the mill at the end opposite the stairway and place a bag of cyanide gently in each jar, passing quickly from one to the other, and from one floor to the next one below, closing the trap door, where the process is repeated until the lower floor or basement is reached where exit is made. The outer doors should be locked.

Hydrocyanic acid gas is extremely poisonous, and if the fumes are inhaled they are almost sure to prove fatal.

Experiments show that below a temperature of from 50° F. to 60° F. most mill insects are inactive and not affected by the gas; a day should be selected for the fumigation when the temperature is 70° F. or above. Everything should be done during the day so that the charge can be set off in the evening before dark. The building should be allowed to fumigate not less than eighteen hours, and, when time will permit, from twenty-four to thirty-six hours.

After fumigation, the windows and doors should be opened from outside the building, for thorough ventilation. The building must not be entered until it has been aired for at least two hours. After this, the operator should enter to open up the stair doors and more of the windows, but should not remain in the building until it has aired for fifteen or twenty minutes more.

The liquid left in jars should be emptied into a sewer or pit, and care should be used not to spill any on the person or in the plant. The jars can easily be washed with water.

As an alternative method, the sacks containing the cyanide may be suspended above the jars by strings pulled through staples and the strings terminated on the outside in such a way that the sacks may be lowered into the jars after the building is locked.

A method has recently been perfected whereby the fumigation by the hydrocyanic acid gas method is entirely operated from the outside. The building is equipped with small copper hollow tubing with spray nozzles distributed through the plant in such position as to get the correct distribution of gas. The liquified hydrocyanic acid gas is shipped in cylinders under pressure, with valve to be attached to the terminal of the tubing system which is located on the outside of building. This system is very effective and when the ordinary precautions are taken is safe. The

nozzles can be placed in grain bins and weevils can be efficiently destroyed by this method.

Heat Method.

The heat method of fumigation when properly applied is probably the most satisfactory. It kills all forms of vermin, larvae and eggs, and, when the equipment is once installed, is cheaper than other methods.

To be effective the temperature should be maintained at 125° F. for twenty-four hours.

Where steam heat is used the steam coils should be placed on or near the floor, since the heat from them rises, and it is very difficult to penetrate the cracks and crevices in the lower part of the room.

In a good brick mill with a steam pressure of 25 lbs. to 50 lbs., one square foot of radiating surface will heat 50 to 100 cubic feet of space. With a steam pressure of 90 lbs., about 75 per cent as much radiating surface will be required.

An idea of the radiating surface required for a good brick building with steam at 25 lbs. to 50 lbs. pressure and how it is distributed, is given by the table.

1st	floor	1 sq. ft.	radiating surface	per	50 cu. ft. space
2nd	floor	1 sq. ft.	radiating surface	per	60 cu. ft. space
3rd	floor	1 sq. ft.	radiating surface	per	75 cu. ft. space
4th	floor	1 sq. ft.	radiating surface	per	90 cu. ft. space
5th	floor	1 sq. ft.	radiating surface	per	110 cu. ft. space

In determining the amount of radiation required, a convenient rule is as follows: first, take the area of all window openings in square feet, add to that one-fourth of the wall surface in square feet; second determine the cubical contents, divide by 50 and add the result to the other two amounts; then multiply this sum by the number of degrees heat you wish to raise (for example, if the temperature of the building is 80° and you wish to bring it up to 125°, multiply by 45, the difference between 80 and 125). Divide this by two times the temperature of the steam.

The amount of radiating surface required may be conveniently determined by the following formula. This applies to a well-constructed brick building; the amount of radiating surface should be approximately doubled for a frame building.

$$R = \left(W + \frac{S}{4} + \frac{C}{50}\right)\frac{H}{2T}$$

Where,

R = No. of square feet radiating surface. (A one-inch pipe has .345 square feet surface per foot of length.

W = Window area, in square feet.

S = Surface area of walls, in square feet.

C = Contents of the building, in cubic feet.
H = Heat to be raised, degrees F. (e.g., if the temperature of the building is 80° F. and it is desired to increase it to 125° F., H = 45).
T = Temperature of steam, degrees F.

NOTE: The temperature of steam at different pressures is given by the following table:

Steam Pressure	Temperature
15	213° F.
30	250° F.
50	281° F.
75	307° F.
90	320° F.

In using the heat method, it is desirable, if possible, to choose a bright warm day, when the temperature is 70° F. or higher, and apply the heat immediately after shutting down. A windy or rainy day should be avoided. All machines, elevator heads and boots, conveyors and spouts should be opened up to give the heat a chance to penetrate.

All openings between floors should be closed and all windows should be protected by paper or blankets to prevent loss of heat. Two thicknesses of building or car lining paper have been found to be the most practicable means of insulation.

There should be a thermometer on each floor and in each division. The men in charge can and should make frequent inspections without inconvenience, and, by the aid of the thermometer, can regulate the temperature. There should be three men on duty, each man making a round every hour, thereby bringing the inspections twenty minutes apart. At every round the reading of the thermometer should be taken and recorded.

Freezing Method.

In northern territory, where temperatures of twenty to twenty-five degrees below zero are not uncommon, the mill may be rid of insects by freezing. In the freezing method a mill is emptied and all windows and doors are opened and left open for four or five days with the result that all trace of insect life is destroyed. The mill must, of course, be provided with suitable watchman service during this period.

Smoke Methods.

There are on the market two processes of generating fumes by heat, either by direct burning of a saturated paper, or by heating a powder on an electric plate, and forcing the smoke into the individual machines by a fan. These processes have been widely used with reported success in many instances. They are, however, too local in their application to be generally considered efficient.

Other Gas Fumigants.

There are on the market a number of fumigants for which the manufacturers claim success. They may be classed under three combinations. The ones having refined petroleum as a base are generally very effective in penetrating the cracks in the walls of a wooden bin, and preparing it for the storage of stock. Those based on carbon tetrachloride, with a sulphide as the principal killing agent, are claimed to be very effective. Difficulty has been experienced in getting the correct amount of sulphide. Too much bleaches the grain, and lesser amounts do not make the gas sufficiently toxic. This combination is being quite extensively used, and is well recommended by many users. Combinations of carbon bisulphide and other agents are quite common, but the more toxic combinations are also the more explosive, generally speaking.

Chloropicrin and Carbon Tetrachloride.

Professor Chapman of the University of Minnesota has perfected and subjected to every possible test a combination of the army tear gas (chloropicrin) and carbon tetrachloride. Baking tests on flour and chemical tests on wheat show that the gas leaves no trace on the product. The gas is very heavy and permeates a bin of grain quickly. It is very much more toxic than any fumigant now used.

It is necessary to use a gas mask in the handling of this fumigant. Chloropicrin is not a deadly poison, but it has an exceedingly painful effect on the eyes, although the eyes are not considered to be permanently injured by contact with the gas.

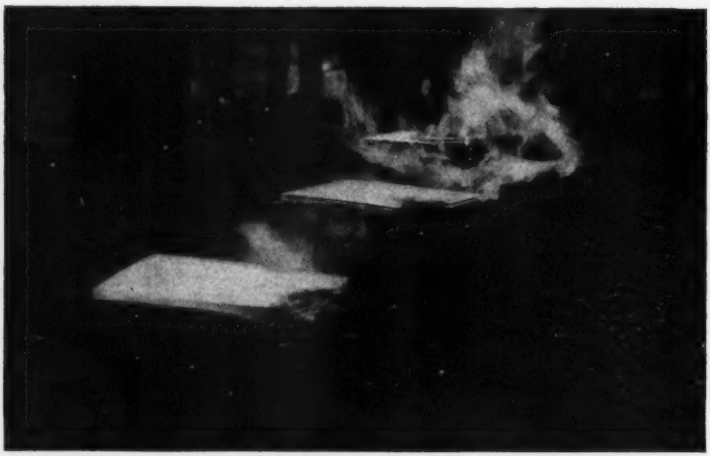
The regulations of the railroads regarding the shipping of poisonous gases have made it impossible up to the present time to interest any manufacturer in preparing this fumigant commercially, but these obstacles are being removed and it is hoped that the fumigant will soon be available.

Film Burning Tests.

A series of burning tests of cut sheet film were conducted on April 3, 1924, at the Kodak Park Works of the Eastman Kodak Company at Rochester, New York. The tests supplemented previous tests conducted by the Eastman Kodak Co. and tests conducted by a sub-committee of the N. F. P. A. in 1915. (See Report of Fire Tests of Nitro-cellulose Motion Picture Films in Various Types of Containers to Determine Proper Size of Pressure Relief Vent Opening, July, 1915, QUARTERLY.) A brief summary of some of these tests follows:

Test C S 9. The object of this test was to determine the relative rates of burning of nitrate and safety X-Ray film negatives packed in manila envelopes (100 lb. tag stock). For comparison a dummy paper test was run simultaneously. Twenty-four developed 14 in. x 17 in. safety X-Ray negatives were packed in six manila envelopes (4 per envelope). In the same way were packed twenty-four developed 14 in. x 17 in. nitrate X-Ray negatives. Twenty-four sheets of 14 in. x 17 in. 125 lb. tag manila paper were packed similarly.

The three bundles of envelopes were simultaneously ignited with blow torches. At the end of one minute and thirty-five seconds the nitrate



Test C S 9. Twenty seconds after the three envelopes were ignited. The nitrate film is burning rapidly. The acetate film (in the middle) is burning slowly as is the paper in the foreground.

Tests C S 10-12. Heavy decomposition gases are coming from the miniature nitrate film vault while a little smoke is coming from the other two vaults. Photograph taken about twelve minutes after ignition.

film was all burned. At the end of seven minutes and fifty seconds the envelopes containing the nitrate film were completely burned, the paper was nearly completely burned, and the safety film and envelopes were 83 per cent intact.

Tests C S 10, C S 11, C S 12. The objects of these tests was to observe the relative action of a fire in an enclosure loaded with nitrate film in one case, safety film in another, and 125 lb. tag manila paper in the third.

Miniature film vaults were constructed, one two-hundredth of the size of a standard vault. These vaults were of pine wood, lined with sheet metal. Two-inch by three-inch vents were open throughout the tests. Forty pounds of developed film or paper was used in each test, being cut into pieces 4½ in. by 5½ in.

The film or paper was packed into manila envelopes and folders, four negatives or pieces of paper to each envelope. These envelopes were distributed at random throughout the shelves of the enclosure.

Dry excelsior on the floor of each test enclosure was ignited.

The nitrate film was completely destroyed when the enclosure was opened after 32 minutes. The paper was 5 per cent destroyed and the safety film was 10½ per cent destroyed.

Burning tests on cellulose nitrate, cellulose acetate and raw materials from which they are made were conducted. Small amounts of nitrated

cotton, raw cotton, wood pulp, tissue paper and cellulose acetate were placed on separate metal screens. Approximately the same weight of material was used in each case and the different materials were rolled into small lumps so as to present similar surfaces. The materials were ignited with the aid of a blow torch and allowed to burn freely. The results were as follows:

Material	Burned in
Nitrated Cotton	6 seconds
Raw Cotton	53 seconds
Wood Pulp	51 seconds
Tissue Paper	40 seconds
Cellulose Acetate	180 seconds

It will be noted that the time of burning for cellulose acetate was 30 times longer than that of nitrated cotton, and 4½ times longer than tissue paper, the material from which it is made. The cellulose acetate melts down to a heavy viscous fluid while burning, and the gases of combustion bubble through this semi-fluid during the burning and give an appearance of boiling. This melting down diminishes the surface exposed to combustion and thereby reduces the speed of burning.

An Underground Gasoline Tank Explosion.

The tank shown in the picture on the next page exploded on December 19, 1923, while it was being filled from a delivery truck, at the Watson Company, Attleboro, Mass. It is natural to ask how such accidents can occur and how they can be prevented.

In this case the gasoline hose was not screwed tightly to the tank inlet as usual, but was stuck into a two-inch opening in the top. Gradually the gasoline vapor formed an explosive mixture with the air in the nearly empty tank. This explosive mixture was directly exposed at the open filling hole to danger of ignition by flame or spark.

The friction of the gasoline flowing through the filling hose generated a charge of static electricity on the metal lining and end coupling of the hose. The metal lining, which is used because it is not affected by gasoline, is covered with a layer of rubber and an outside jacket of cotton. These coverings insulated the lining so that the charge of electricity gradually accumulated until it became great enough to jump to the tank shell. The resulting spark ignited the vapors from the stream of gasoline. Immediately realizing the danger, the truck driver and the mill piper who was with him started to run.

Reprinted from the initial issue of the *Factory Mutual Record* published by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies (Member N. F. P. A.).

Effect of Explosion in Buried Gasoline Tank.
19,000 gallon capacity. Originally covered with six inches of earth. The house was not as near the tank as it appears to be in the picture and was not damaged by the fire.

The piper stumbled and fell directly over the tank just as it exploded. He was blown a distance of fifty feet, his clothing on fire, and was killed, probably instantly. The truck driver escaped injury.

The force of the explosion lifted one end of the tank out of the ground, as shown by the picture, and blew out the head, breaking off a 6-inch water main which was less than a foot away.

The fire was controlled by hose streams and by shoveling dirt on to it. The break in the main drained both sprinkler tanks and made it necessary to shut off the city water until the break could be repaired.

The danger of the open filling hole in the tank can be avoided by having a fill pipe that makes a tight joint at the tank shell and extends down inside the tank to the bottom. In this manner the interior of the tank is cut off by a seal of gasoline, and the only exposed surface is inside the small pipe. Sparks of static electricity can be prevented by coupling the hose directly to the fill pipe described above. This provides a path for the electricity to leak off as fast as it is generated, for the tank is well grounded by being buried in the soil.

Even if the hose had had no metal lining and merely a coupling or nozzle at the end, this accident might have happened from the electric charge accumulating on the metal tip. An all-rubber hose would have

been safe from this danger, but it would not have permitted a tight connection to be made to the tank. A tight connection is a desirable arrangement with any kind of hose, in that it prevents the accidental escape of gasoline, which would introduce an additional hazard.

This accident also emphasizes the value of keeping tanks of hazardous liquids buried, and at a safe distance from fire-service mains and buildings.

Kerosene in Kansas.

This picture shows the remains of an exploded kerosene oil can which was used in kindling a fire at Parsons, Kansas. A mother and her nine-year-old daughter were starting a fire early in the morning. Fire was apparently drawn into the can which exploded, throwing the burning oil over both of them. The little girl died the next day and the mother was so severely burned that she remained in a hospital for three weeks. Owing to the quick response of the fire department, loss to property was negligible.

The use of kerosene in starting fires was responsible for 79 of the 137 deaths in Kansas caused by fire in 1923.

Metal Working Processes.

By W. D. Milne.
(Member N. F. P. A.).

In an article on Iron and Steel Works by the writer in the January, 1920, QUARTERLY (Vol. 13, No. 3, p. 251), the processes and hazards of plants devoted to the manufacture of iron and steel were outlined. These processes, particularly "conversion" (the converting of pig iron and ore into steel) are referred to several times in the following article.

The product of these plants becomes the raw material for many kinds of metal working factories, in which by various processes the metal is transformed into the products used in engineering work or in commerce. This article is devoted to a description of these processes and their hazards, and treats the subject according to classes of processes, rather than classes of occupancy. This method of treatment is felt to give the best understanding of the subject, for the processes described, with their attendant hazards, are found in many different classes of occupancy.

The several processes described are classified as follows:

A. Heat Processes
   1. Rolling Mills
   2. Forge Shops
   3. Foundries

B. Forming and Cutting Processes
   4. Boiler Shops, Bridge Works, etc.
   5. Metal Stamping
   6. Machine Shops
   7. Cutlery and Edge Tool Manufacture

C. Metal Finishing Processes
   8. Finishing Metal Workers—general
   9. Welding, Brazing, Soldering
   10. Galvanizing, Tinning, Blueing
   11. Plating

D. Painting and Enamelling Processes
   12. Painting, Enamelling and Similar Finishing
   13. Dipping
   14. Spraying
   15. Ovens and Dryers

The fire record on metal working processes (p. 78) which follows this article follows the same classification of processes, and should be referred to in connection with the various hazards described.

A. Heat Processes.

1. Rolling Mills.

Raw Material.

Steel ingots, billets.

Product.

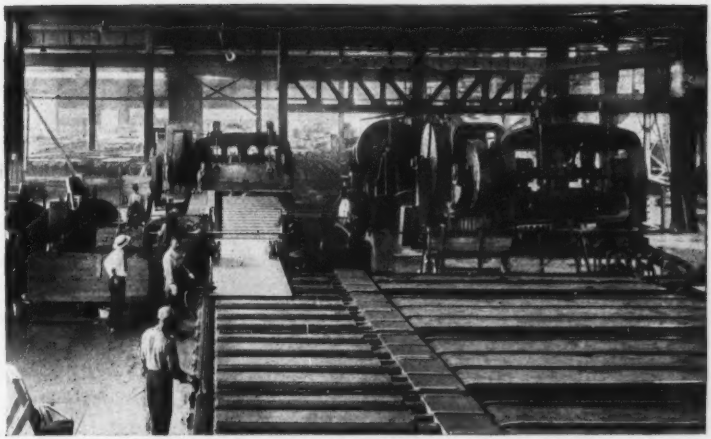
Steel bars, rails, rods, structural steel shapes, sheets, etc.

Processes.

Mechanical work on steel not only transforms the material to the desired shape, but considerably increases its strength. Rolling and forging both accomplish this, the rolling by the pressure slowly applied by the squeezing action of the rolls, the forging usually by pressure applied by impact. The strength and ductility of steel are greatly affected by the temperature during the period when mechanical work is being done on it. Steel, which in the ingot may have a tensile strength of 10,000 to 20,000 lbs. per square inch and a low ductility, may, after rolling, have a tensile strength of 55,000 to 65,000 lbs. per square inch, and possess a high ductility. Cold rolling increases the ultimate strength and hardness but gives a lower ductility. Annealing increases the fineness of the grain of the metal and relieves internal stresses due to mechanical work done on the material. Tempering, done by heating to certain temperatures and cooling under certain conditions, is resorted to in order to secure desired characteristics of strength and elasticity required in steel, for special uses.

The rolling mill, according to the type of its product, embraces the rolling process proper, and sometimes annealing, and tempering. With the exception of some wire mills, rolling mills are generally associated with, or are a part of, steel conversion plants, and receive from them the hot ingots.

The ingot molds, standing on iron cars, receive the molten steel from the converters and rest on side tracks until the ingots have cooled to proper working temperature, or they may be transferred to "soak pits" or to a heating furnace where the temperature is kept up or raised as desired. When the rolling mill is ready for material, the ingot cars are run to the "stripping shed" where the ingot mold is stripped from the hot ingot. The ingot then travels, usually on a roller conveyor, up to the breaking down rolls, and is reduced in cross section by several passes through these. In a typical operation of this sort for rails, an ingot weighing, say, 3 tons and being about 18" square in the middle



Courtesy Youngstown Sheet & Tube Company (Member N. F. P. A.).

View in sheared plate mill showing portion of roll tables, cut-off shears, and plate warehouse in background.

section is reduced to about 8" square in nine passes, the length, of course, being materially increased. After this operation, a considerable length, that rolled from the top of the ingot, is cut away, on account of the "pipe" or imperfect area formed in the middle of the top during the cooling. A section of the other end, made ragged by the rolls, is also cut away. The parts cut away are sent back to the converters for remelting. The remainder is usually cut into two "blooms." According to whether the ingots are being made into bar shapes or sheets this part of the mill is termed a "blooming mill" or a "slabbing mill."

The rapidity with which the great hot ingots travel in the blooming mill process, and the massiveness and power of the machinery used make this portion of a steel plant fully as awesome a picture to the visitor as any other, even the converter buildings. The breaking down of the ingots and the cutting of the blooms usually proceeds so rapidly that the metal is still sufficiently hot to permit the subsequent rolling operations to reduce it to the finished shape without reheating, but intermediate reheating in gas or fuel oil heated furnaces may be resorted to at any stage of the rolling. For most varieties of rolling mill product the final rolling is done with the metal at a comparatively low temperature or cold.

All rolling mill work is similar but there are several types of equipment worthy of mention. The simplest type has a single pair of rolls, the work passing through the rolls and being dragged back to pass again in the same direction. This is the "two high" roll, and like others may have "open," "closed" "diamond," "flat" or "round" openings for the

work, according to the results desired. A "three high" roll is arranged to reduce the labor, allowing work to be done on the material as it passes in each direction. Some "two high" mills are arranged with a reversing drive to accomplish the same result. In the heavier classes of work there may be but a single pair of rolls, or "stands" but it is not unusual to see four or more "stands" of rolls side by side on the same shaft, where steel of small cross section is being worked.

The incidental processes in a rolling mill entail the presence of long "cooling tables," the use of heavy shears, large heating or annealing ovens, and sometimes oil tempering baths. The power requirements are very heavy and the engines or motors are usually located close to the rolls themselves to permit economies in transmission equipment.

Special forms of equipment are of course necessary for the manufacture of lap welded tubes, seamless tubes, drawn wire and other special shapes. As the particular forms of equipment for special rolling mill work have little bearing on the character of the plants as fire risks, no attempt will be made to describe them here.

Features of Fire Hazard.

Typical construction in modern large rolling mills consists of very long buildings with one high story, built of steel framework with metal siding and roof. Such structures seem to present little opportunity for serious fire, when the nature of the material ordinarily within them is considered. Wood employed in any structure of the size ordinarily used for rolling mill occupancy, considerably reduces the relative merit of the property as a fire risk.

The movement of hot metal through the plant is of course a hazard, the importance of which is largely determined by the amount of combustible material that may be in proximity, either in the structure or its contents.

Annealing or heating furnaces and their stacks present hazards determined by the character of the surrounding construction. The long continued high heat of such devices precludes the use of wood in the structure if safety is to be secured. Fuel oil equipments in connection with such furnaces may prove serious hazards, and especial care should be taken to protect oil pipes against breakage from vibration, the movement of heavy material or the operation of cranes, etc. The provision of adequate means for controlling the flow of oil, from convenient points inside and outside the area where the oil is burned, is essential. Main supplies of oil should be located outside the buildings, preferably in underground tanks. The proper arrangement of fuel oil systems is a very important matter, as even superior structures are not proof against oil fires, as experience has shown.

Baths of tempering oil, often very large, involve opportunities for serious fires. The oil, becoming first thoroughly heated by the hot metal plunged into it, may finally be ignited. Such fires are difficult and dangerous to extinguish on account of the heavy smoke formation and the boiling of the oil. Mechanically correct, and easily operated covers of heavy design should be provided, also ample foam type extinguishing equipment. Adequate cooling facilities should be provided for keeping the bath at proper temperatures during operation. (See Forge Shops.)

The rolling mill engines, frequently in pits, and heavy shafts sometimes set below the floor, present chances for serious fires in the oil and oily material which accumulates in such locations. Motors and transformers, especially on reversing mills, being subject to overloads and sudden changes of load, are perhaps more susceptible to breakdowns than ordinary electric equipment. Special care should be taken with respect to the power equipment.

2. Forge Shops.

Raw Materials.

Steel billets, bars, and in some cases, steel castings or ingots.

Product.

A wide variety of shapes of steel for engineering and manufacturing uses, including such articles as cannon, armor plates, projectiles, engine shafts, crank shafts, cutlery and tool blanks, etc.

Processes.

Forging is the process of shaping metal by hammering. The mechanical work done in this way, greatly increases the strength of the material, bringing about a fineness of grain and a uniformity of structure necessary to strength. It accomplishes by a series of sharp blows, but more effectively, the same result in the structure of the material that rolling does through pressure slowly applied. Not all forging can be exactly described as "hammering" as some is done by hydraulic presses, in which there is continued pressure as well as, in some cases, impact. Forging done by hand, as in blacksmith shops, repair shops, etc., involves the same fundamental operations as are required for heavy work. Upsetting, drawing down, setting down, cutting out, bending, punching, welding, and stamping are the technical terms for the several mechanical processes of a forge shop.

The general appearance of a forge shop depends to a marked extent upon the size and nature of the work being done. The equipment varies from massive steam hammers used in forging armor plate to the hand hammers used in the blacksmith shop. Hydraulic hammers or presses are used on much of the medium weight work, such as projectiles, and in

shops employing this equipment, the system of pumps and accumulators for furnishing the hydraulic pressure is necessary to the operation of the plant as a whole, and consequently deserves careful protection against fire. Drop hammers and trip hammers, operating on cams, are employed on light work such as cutlery and edge tools.

Recent practice in forge shop construction has been to employ brick, steel and tile or all metal, and with such structures the danger of serious fire is small provided there is adequate safeguarding of the oil hazards. Many forge shops of wooden construction have been destroyed by fires due to the proximity of the forge fires to woodwork, the flying of sparks, or to faults in fuel oil systems. The numerous forge fires in close proximity to drop or trip hammers in light forge shops, with, frequently, oil baths in addition, render such places peculiarly subject to fire if there is woodwork in the construction.

Forging requires the initial heating of the metal to a temperature at which it can be worked; also, if the operation be long, reheating at intervals. Annealing, that is, heating and slow cooling, is also often required to relieve internal stresses set up by the work, while the properties of the steel in the finished article may be fixed by tempering. In some cases hardening also is required. Annealing, hardening and tempering are important processes, and to avoid repetition a general statement in regard to each will be made here.

Annealing.

Annealing consists in thoroughly heating a material to a temperature below its melting point and allowing it to cool slowly. The process is supposed to give homogeneity of structure and to relieve the internal stresses set up by cooling or by work done on the material. Brass or steel if worked by forges or presses through considerable changes in shape will crack unless annealing or reheating is done at certain steps in the process. Proper annealing is an essential preliminary operation to hardening and tempering of steel for blades and tools. Annealing furnaces or "ovens" vary in size and construction according to the needs of the work. They are usually direct fired, that is the flames and gases of combustion play on the material being heated. In some cases annealing is done in special ovens to prevent oxidation of the surface of the metal. Furnaces may be fired by coal, wood, fuel oil, or gas, though some care must be taken that impurities in the fuel, such as sulphur, do not affect the metal. Annealing furnaces constitute important hazards, the degree of danger being influenced by the surrounding construction, the kind of storage and method of handling of the fuel, and the care of the operators. As such furnaces, for convenience in the routing of materials in process, must frequently occupy interior locations in large buildings, their ar-

rangement should be carefully made to secure safety. The long continued heat of the ovens and the heat radiated from the metal withdrawn from them reduces nearby woodwork to such a condition that ignition is easy. In modern steel plants annealing ovens are usually set at one side of the building, being projections therefrom, and the building itself is of non-combustible construction throughout. Unfortunately, annealing processes on a smaller scale, but no less hazardous, are often found in buildings of wooden interior construction.

Hardening.

Hardening may be described as the process of quenching in water or some similar medium such as oil. Quenching in oil, lead, etc., makes the metal less hard and brittle, and this operation is termed "tempering." Hardening by quenching is not to be confused with "case hardening." The theory of hardening and tempering processes is somewhat involved, but it is sufficient to state that by heating steel to the proper temperature and then quenching it, certain properties of hardness and toughness may be produced more or less at will. Case hardening, being a process identified with the manufacture of articles from steel, will be described later.

The hardening or quenching process presents no special dangers of fire other than those of the furnace where the metal is heated.

Tempering.

The cooling of steel from a temperature above a certain critical point by quenching it in a bath of oil, molten lead or similar medium, is known as tempering. More accurately, though less commonly, the term is used to describe the process of reheating hardened steel to the desired temperature and then quenching in oil. Practically all tempering is done from temperatures between 390° and 570° F. (200° and 300° C.)

In addition to the furnaces for heating, the oil baths used in tempering present important fire hazards, as indicated in this connection in the section on Rolling Mills. Considerable bodies of oil may be required where the work to be tempered is of large size, as with cannon barrels, or is produced in quantity. In some cases the oil must be heated to secure proper tempering. The oil if overheated by the passage of the hot metal may easily become ignited, in which case a fire difficult and dangerous to handle quickly ensues. Hoods and vents should be provided over the oil baths. Facilities for keeping the oil at proper temperature by circulation of water in a jacket about the bath, or by the circulation of the oil itself through cooling apparatus, must be adequate and must be carefully watched. Overflow, or automatic bottom drains for the tanks, heavy and properly arranged covers, and foam extinguishing apparatus are essential measures of protection. Care must be taken to secure oils of high flash point and uniform quality.

Heat Treatment.

The processes of annealing, hardening, and tempering are frequently called "heat treating" processes and the heat treatment department of a metal working plant is an important one, not so much on account of the number of fires which occur in connection with it, as the severity of the fires that do occur.

Hazards.

The following list of items requiring special attention will serve to summarize the hazards of forge shops: Construction, arrangement of furnaces, fuel oil storage, oil burning devices and their control, oil baths and temperature regulation of tempering oil. Incidental processes which may include grinding, acetylene cutting, etc., also should be given attention.

3. Cast Iron Foundries.

Raw Materials.

Ingots of pig iron, and scrap steel and cast iron, together with coal or coke form the principal materials entering into the product. The coal or coke acts in a dual capacity, furnishing as fuel the necessary heat for melting the iron, and also supplying carbon to give the required composition. The incidental materials include sand for molds and cores, fire bricks and fire clay, lumber for flasks and patterns, japan and paints, and graphite, charcoal, molasses and other preparations for use in making sand molds and cores.

Product.

The product of an iron foundry is iron castings and of iron castings there is an almost infinite variety in size and shape. The arrangement and equipment of the plant will depend somewhat upon whether the individual castings are few and large, or numerous and small. In either case the processes are fundamentally the same.

Iron castings contain iron in a very impure form, and it is the art of the iron founder to so regulate the proportions of iron and carbon, and other impurities that the desired properties will be secured in the product. Silicon, manganese, phosphorous and sulphur present in the cast iron in small percentage, affect the character of the product materially. The rate of cooling of castings has an important bearing on their strength, this process affecting the ratio of combined and precipitated or graphitic carbon. In the common so-called "gray iron" castings there is about 4% of carbon, and nearly all of this is free and in the form of graphite crystals. It is this material which imparts the gray color to a fracture. White iron castings may contain the same percentage of carbon, but all in the combined form, so that the material is of much greater strength, and of clear white fracture.

Processes and Hazards.

Briefly described, the processes of an iron foundry are as follows: The charge of pig iron, fuel, and scrap iron is melted down in the cupola. The molten metal is drawn into ladles and poured into sand molds. The castings after cooling are cleaned of adhering sand, and chipped, rattled, filed or sand-blasted as occasion may require, to bring them to a clean, smooth surface. They may be acetylene welded or cut, and in some cases they are protected by asphaltum paint or by japan.

Woodworking processes incident to the making of patterns, molds, and flasks are frequently present in the foundry plant, together with more or less extensive storage of patterns and flasks. Machine shop processes are also usually found here. The making and baking of sand cores may be a considerable element. The size and importance of these latter departments of the foundry plant will vary materially according to the class of business done.

The following is a description of the more important elements of a foundry plant, with notes on features affecting the fire hazard.

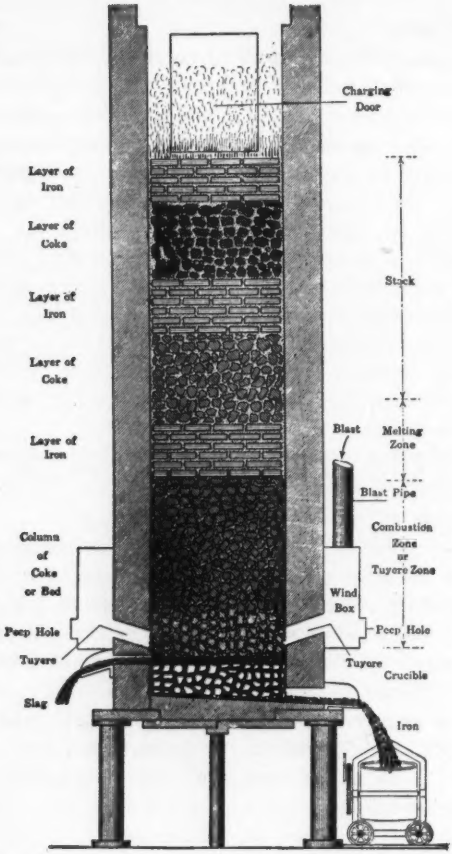
Material Bins.

Pig iron, scrap, coke, and sand are used in considerable quantity, and the storage of these materials must be arranged to effect greatest economy in handling. Bins for these materials are frequently located parallel to a railroad spur track and along the cupola side of the foundry, so that the distance the heavy materials must be carried is reduced to a minimum. Buildings to protect the material from the weather should be of substantial construction on account of rough usage, and if the structures are of rambling wooden construction they may on account of their proximity to important buildings form an element of some importance in the fire risk.

The Cupola.

The cupola of an iron foundry closely resembles the blast furnace used in pig iron manufacture, except that it is usually smaller. There may be one or several cupolas according to the size of the foundry. The cupola is an upright cylindrical iron shell lined with refractory brick and fire clay. Beginning at the top there is the metal chimney, charging chamber and door, stack, melting zone, tuyère zone, tuyères, slag tap hole, and iron tap hole. The whole is usually set up on legs off the foundry floor level so as to facilitate the cleaning out of the cupola and the drawing of the iron into ladles. The inside diameter may be from 36 in. to 84 in. but usually is not larger than 60 in.

In charging the cupola a deep bed of coke or hard coal is laid in the bottom, then alternate layers of iron and coke, usually three of the former. The iron consists of pig iron and scrap selected to give proper



Courtesy McGraw-Hill Company.

Typical arrangement of a cast iron cupola.

composition. In some cases, powdered marble or limestone may be used as a flux. The fire is started in some plants with kindlings, but more frequently by means of a portable fuel-oil-burning equipment. This fuel oil equipment is also used in drying out the cupola and ladles. The air blast furnished by powerful blowers, enters the cupola through the tuyères (pronounced "tweers") or openings arranged around the lower part just above the iron tap hole. The ordinary run of a foundry cupola is only three or four hours. The fire is usually kindled about noon, and the air blast put on about one o'clock, the charging and melting going on until about four o'clock. After the molten iron has been tapped and

carried, wheeled, or run to the casting floor, the supports are pulled out from a door closing the bottom of the cupola, and the mixture of sand, slag, and coke remaining is allowed to drop, and is quenched with water.

The blower is an important part of the foundry equipment. Large blowers of the positive displacement or impellor type, somewhat similar in design to rotary pumps, are largely used, the Root type blower being popular.

The fire hazards of the cupola and its surroundings would appear to be fairly evident, but the persistence of occurrence of fires due to faulty construction seems to show that the danger from the long continued high temperatures is not fully realized when the cupola housing is designed. The presence of wood in any part of the cupola house roof, charging floor, or walls should be regarded as a defect. Fires often occur on account of proximity of woodwork of the roof or charging floor to the shell of the cupola, and in providing clearances for existing wooden roofs or floors, at least four feet should be allowed. Ventilating collars leaving a space for circulation of air next the shell of the cupola should also be provided.

Sparks discharged from cupola stacks alighting on combustible roofs, in accumulations of rubbish or wood waste, or even entering windows, very frequently cause fires, and both foresight and constant watchfulness are necessary to avoid trouble from this source.

The necessity of dumping the slag below the cupola, together with the practice of storing wood and kindlings at times in the cupola room, leads to fires, and is an argument for the use of fire-resistive or non-combustible construction throughout this area.

The usual location of the cupolas is at one side of the large, high roofed casting shed, in a sort of lean-to structure. This arrangement makes it possible to use non-combustible materials in the cupola housing, and a plank roof over the larger casting area. The proximity of the cupola to the wooden roof, however, has in many cases given trouble, and care should be given to the conditions at this point.

When the cupola is tapped, the heat radiated from the metal is very considerable and there is danger of fire from this source as well as from splashes of hot metal. Occasionally, the charge of hot metal escapes from the cupola, and in such cases there is danger of fire if any combustible material is near. The circumstances are such as to warrant the use of non-combustible or fire-resistive materials of construction not only throughout the cupola house itself but for a goodly area in the casting shed in front of the cupolas. The difficulty of maintaining automatic sprinkler protection in the area about the cupolas on account of the wide range of temperatures and the high studded rooms, argue for the use of superior construction.

The Casting House or Foundry Proper.

Large open areas in a foundry plant are used as casting floors. As the molten iron is drawn from the cupolas it is received in ladles and carried to the molds prepared and laid out on the earth floor. For heavy castings the ladles are large affairs carried on a travelling crane or suspended from overhead track. For lighter work, the ladles may be carried on wheeled carts or by the workmen themselves. The carrying and pouring of the hot metal entails some hazard from spillings alighting in combustible materials, and not unfrequently smoldering fires are started in the wooden flasks.

The casting room itself is not so often the point of origin of serious fire as is the cupola house though in event of the breaking of a cupola, the overturning of a ladle, or the explosion of hot metal due to contact with water, fire may be started in the roof structure. Foundry roofs are usually of large area on long span trusses and fire in such places frequently proves difficult to combat. Plank roofs for foundry buildings seem to have predominated in the past, but modern practice tends to the use of tile, corrugated asbestos, or metal.

Sprinkler protection for large casting rooms is a somewhat uncertain factor. The high temperatures incident to the pouring operations may require the use of high test sprinklers in certain areas. Reliance for heating is frequently placed on the cupolas and the hot castings so that if wet pipe systems are employed they may be out of service in cold weather when the foundry is not operating. Dry pipe systems are advisable in most cases. With non-combustible construction throughout, and outside storage for flasks, complete sprinkler protection in many cases is hardly necessary for proper safety in the casting room.

Pattern Making.

The making of the wooden patterns for molds and cores involves woodworking processes of an ordinary nature. If the foundry is largely engaged on special work rather than on standard quantity production, the volume of work in the pattern department may be considerable, and the variety and number of the patterns kept on hand may be great.

The pattern shop, quite appropriately, is often a distinct unit, and may well be in a separate building. It presents usual hazards of woodworking, these sometimes accentuated by the lack of adequate means for the removal of wood waste.

Pattern storage buildings are often quite extensive. In some works the question of providing proper storage space for bulky and numerous rarely used patterns is an embarrassing one. The first cost of the patterns may have been considerable, and their future value a matter of considerable doubt. In many cases obsolete patterns are preserved for years.

It may be difficult in case of fire involving patterns to arrive at a fair estimate of the current value of patterns destroyed.

The tendency of modern practice appears to be to provide more or less detached buildings of non-combustible construction to house inactive patterns, and more accessible, well protected buildings for the active ones. It would appear that if patterns are worth keeping they are worth protecting in accordance with the degree of protection furnished for the other portions of the property.

Molds and Core Making.

Founding consists of pouring melted metal into a mold of desired shape and form which the metal assumes and retains when cold. The art of making the molds is a complex one, requiring a high degree of skill, but as the molding department is not of particular importance as effecting the fire risk, only brief mention will be made of the processes involved.

Molding ordinarily consists in ramming sand or sand clay mixture in place about a pattern, and then so removing the pattern and finishing the surface that the outline of the casting will be perfect. Some molds are built up by hand around the pattern, but for most small castings machines are employed. If the mold is used after ramming, and applying the "wash" to the surface it is termed a "green sand" mold, while if it is dried or baked in an oven, it is termed a "dry sand" mold. The "flask" is a wooden or iron frame or box confining the sand of the mold. The mold is usually divided symmetrically to facilitate the removal of the pattern. A hole is left in each mold for the pouring of the metal and perforations are made with wire to permit the escape of hot gases. Occasionally iron, clay or plaster of Paris molds may be found in use.

Cores, set within the molds, assist in forming hollow castings. Being subject to great heat and pressure from the metal, the cores are built up of sand bonded with linseed oil, flour paste, or other special compound which will burn away and allow the sand to disintegrate. This prevents the casting being burst by its own contraction, and permits of its being more easily cleaned out. Cores are usually baked before use, in order that gases generated from the bonding material when heated will not affect the casting. The making of small cores is largely done by machinery, machines also being used in the preparation of the sand. Core oils containing linseed oil, fish oil and similar materials, in contact with waste, etc., may be subject to spontaneous heating.

The core oven presents the chief fire hazard of interest in this department of the plant. It may be coke, coal, or fuel oil fired, but the temperature carried is not usually very high. The provision of proper clearance for the stack, and proper care of the fuel, are matters of im-

portance, but fires occasionally occur in the ovens and their vent pipes due to accumulations of soot. Proper clearance for the oven, its vent, and the stack are required as for any furnace. Wood fuel should be kept away from the fire box.

Flasks and the Flask-yard.

Piles of wooden flasks in the casting room may present sufficient combustible material for a fire of some magnitude and since the hot metal of the casting operation frequently ignites the flask or leaves it smouldering, fires are not unlikely. Flasks should be piled outside the buildings and away from them. Care should be taken to extinguish any smouldering fires. Wooden flasks soon become badly charred and in this condition are especially subject to easy ignition.

Finishing Castings.

After removal from the mold, and cooling, the rough castings are cleaned of adhering sand by "rattling" or sand blasting. Fins and rough places due to defects in the mold are chipped off. Cutting by acetylene or oxy-hydrogen blow torch is not infrequently resorted to in order to bring the casting to its finished shape.

With the exception of the blow torch work, none of these processes present any marked fire hazard. The acetylene and oxy-hydrogen equipment, however, is important in this respect, and care should be taken to locate and arrange it in accordance with the standard rules.

Castings are frequently given protective coatings of asphaltum paint, or are japanned. In either case, fire hazards are involved. Where paint or japan is applied by dipping, the dip tank hazard should be isolated and protected according to established rules. The japanning process in foundries has not infrequently been the cause of fires. The dip tanks with their benzine thinned japan are often found in close proximity to the fire heated ovens, and the whole process poorly cut off from other areas. The japanning process and its fire hazards is elsewhere discussed in detail, but it is well to note here that the essential provisions for safety include the isolation of the dipping process from the firing chamber of the oven, and the use of properly ventilated, indirect heated ovens. Oven explosions and fires occur with some frequency. They can be largely avoided in indirect ovens if the volatile matter in the japan is allowed to evaporate before the work is put in the oven, and if the oven is thoroughly ventilated during the first stages of the baking. Proper clearances should be provided for the vents and smoke pipes, and the method of firing should be safe. Care in operation is an important factor. Unsafe equipments have long operated without trouble under experienced care, only to give serious trouble when an inexperienced man attempted operation. (See subsequent sections of this article on japanning and ovens.)

Malleable Cast Iron.

Much cast iron such as is used on agricultural implements, for railway supplies, for harnesses, and for pipe fittings, etc., must be of greater strength than that ordinarily produced in the cupola. Malleable iron, so called, contains lower percentages of carbon and impurities than ordinary cast iron, and is produced by casting white cast iron and then annealing the castings so that the combined carbon and iron will be in the proper proportions. Malleable iron resembles cast steel in respect to its properties rather than cast iron.

Malleable castings are sometimes poured from iron melted in a cupola, but as a rule reverberatory or open hearth furnaces are used, and this difference, together with the added feature of the annealing furnaces, makes the general appearance of a malleable iron foundry vary from that of an ordinary foundry, although the incidental processes are much the same.

In the reverberatory furnace the metal is melted on a shallow hearth by the radiated heat of flame playing over and on it. Furnaces of this type in a malleable iron foundry are usually long, low affairs built of brick with cast iron clamps and stays. They may be arranged for charging from the end, side, or top, and may or may not be regenerative in their operation. (See further description of reverberating furnaces in QUARTERLY, January, 1920, page 258.)

Malleable iron castings are usually of small size, and many are made from one melt of iron. After the castings have been thoroughly cleaned of sand by rattling, tumbling or sand blasting, they are baked in "saggers" or "annealing pots" or "boxes" with crushed iron oxide, such as iron-ore or mill scale, or sometimes in sand, clay or lime, and annealed. The effect of the iron oxide packing is to extract the "temper carbon" from a surface zone on the casting, producing what is known as "black heart" castings. These are very strong.

The annealing furnaces are of fire brick construction, suitably stayed. The flame enters at the top, passes downward through the pile of annealing boxes and vents at outlets from the bottom to a stack. Six days are usually required to complete the annealing, including the time for heating up and cooling off.

The fire hazards of a foundry of this type are similar in character to those of an ordinary foundry, though the particular construction required for safety around the furnaces will vary in form from that usually found at cupolas. The usual precautions with respect to fuel, furnaces, hot stacks, hot metal and flasks must be observed. Modern foundries, with non-combustible type of construction may present a very small fire hazard.

B. Forming and Cutting Processes.

4. Boiler Shops, Bridge Works, Etc.

The plants engaged in the manufacture of boilers, tanks, bridge trusses, building framing, etc., present similar characteristics of processes and hazards.

Raw Materials.

This consists chiefly of the plates and structural steel shapes produced in rolling mills, with incidental rivets, paint, etc.

Product.

Boilers, tanks, towers, trusses, columns, and structural works of great variety.

Processes.

Plants of this character usually include drafting offices where the designs are made in detail, and lofts where templates for the work may be laid out on the floor. The work on the metal includes cutting by shears and power saws, punching, drilling, bending, acetylene cutting, riveting, assembling, etc. The buildings are usually of large area with one high story. Travelling cranes are employed to move the material. Extensive areas whether inside or outside buildings may be given over to the storage of the steel and the assembled work.

Hazards.

The dangers of fire from processes in works of this character are usually neither numerous nor severe. The machinery is heavy and slow moving. The metal in most cases is worked cold. Fuel oil furnaces may be employed in connection with bending, or with annealing. Coal or charcoal forges, oil fired heaters, or electric heaters may be used for heating rivets. Acetylene, with oxygen or hydrogen, is frequently used extensively for cutting where the work is of irregular pattern, and the arrangement of the acetylene generator may be an important factor. Hot rivets falling in combustible materials, or sparks from cutting torches are not unfrequent causes of small fires. As a rule, favorable conditions of construction and absence of combustible material in quantity serve to prevent the extensive spread of fire.

5. Metal Stamping Works.

Raw Material.

Flat Steel.

Product.

A wide variety of articles, ranging from car wheels to light metal toys. Many of the formed metal parts which appear in automobiles, toys, fixtures, and the light machines of common use are cut and pressed

from plate or sheet iron or steel. Kitchenware and enamelled ware of various kinds requires metal stamping processes.

Processes.

Metal press work or stamping is usually carried on in conjunction with other operations of machine work, japanning and assembling incident to the production of some special article, and therefore appears as a department of a more or less extensive plant. In some instances, however, the predominating processes in a plant are those of cutting out the blanks from the strips or sheets of metal by automatic machines, and forming these by means of a die in an automatic press. Oily conditions usually exist where work is done. "Pickling" to clean the work of dirt and scale is a process common to works of this character. Finishing processes such as lacquering, japanning, painting or galvanizing are frequently found. Soldering and welding may also be done. (See subsequent description of these processes.)

Hazards.

Except for the oily conditions likely to exist throughout a pressed metal shop on light work, there is little to suggest serious danger of fire. On heavier work annealing furnaces may form important hazards. Lacquering, japanning, tinning, welding, soldering and painting processes, if present, increase the hazard materially. Works of this character, especially if engaged on more or less uncertain job work have a rather poor reputation as fire risks. This is probably due to poor housekeeping in conjunction with oily conditions and the hazards of japanning or lacquering.

In the manufacture of enamelled ware for household utensils, etc., the metal stamping or forming processes are followed by the application of an enamel of a porcelain or siliceous nature, not in itself hazardous but requiring the use of high temperature furnaces for melting, and of annealing ovens for cooling the goods after application of the enamel. The hazard is dependent upon the furnaces and their insulation, the fuel and its use. It is characteristic of such operations that a considerable amount of imperfect product is made, the problem of disposing of this material to advantage sometimes being a difficult one.

6. Machine Shops.

The term "machine shop" is a general one applied to that class of metal working plants in which the predominating processes are those of milling, planing, turning, drilling or otherwise shaping the metal by cutting it with machine tools. The general appearance and arrangement of the plants so engaged varies according to character of the product, and particularly according to its size and weight, but the underlying

processes and hazards are closely similar in all. Strictly speaking, a plant should not be classed as a "machine shop" if it houses casting, forging, heat treating, japanning, assembling, or other such processes of more than a very minor nature.

Raw Materials.

In general, the raw materials of a machine shop are brass, iron, or steel castings, rods, bars or plates, and such oils, emulsions or solvents as may be used in the cutting processes or in cleaning the work.

Product.

The product of heavy machine shops includes finished engine and machine parts, of which there is an almost infinite variety. Light machine shops produce a wide variety of the small metal parts which go to make up the elaborate machines, engines, vehicles, etc., of the present day. In this class fall the automatic screw machine shops which make the multitude of machine screws, nuts, etc., required in all branches of the metal industry. In the same class are the shops making machine tools, chucks, drills, etc. Machine shop products are rarely finished goods of commerce, but rather the furnishings in the way of parts, fastenings, and tools with which finished goods are fashioned. Thus the machine shop is more frequently a component part of a larger plant, than a distinct property in itself.

Processes and Machinery.

The processes of a machine shop are those of cutting metal. Elaborate and ingenious machines which are to a large extent automatic in their operation have been developed for many classes of special work of this nature. Turning lathes, automatic screw machines, planers, boring mills, drill presses, and milling machines constitute the more common types, but of these there is a great variety according to the special needs of the product. They may be equipped with individual or group drive motors or be belt and shaft driven according to their size, the nature of the work and the circumstances of the shop. In almost all cases they are of fairly rugged construction and of such a nature as to be not highly susceptible to damage by fire.

Hazards.

Excluding from consideration the metal working processes, which are not strictly machine shop processes as indicated above, the hazards of fire are limited to those of power and its transmission, of hot metal chips and turnings, of oil used in cutting, of kerosene or gasoline used in cleaning, and spontaneous heating of metal turnings or filings.

The hazards of power and its transmission are common hazards and need not be discussed here further than to say that heavy loads are some-

times put on the motive power in machine shops, and at such times the danger from hot bearings, slipping belts, or overheated electrical devices is present.

Metal turned off as chips or turnings by high speed machines may sometimes be hot enough to ignite waste or combustible material against which it falls.

The use of oils for lubricating purposes and for cutting entails important hazards. The action of tools in cutting metal is greatly facilitated by the use of oil, and this together with the necessity for cooling the tools results in the use of a constant jet of oil applied to the point of contact of the tool and the work. The same jet may be utilized to assist the removal of chips. The practice in regard to cutting oils, and the character of the oils used varies considerably, but in all cases where oily conditions exist or oil is circulated in quantity, careful attention should be given to potential hazards.

The lubricant for cutting tools may be simply water, in which case there is, of course, no hazard. The use of emulsions of oil in water is very extensive, and in such cases the hazard is materially less than it would be with a corresponding amount of oil alone. Nevertheless there is a hazard on account of the nature of the oil used. Emulsions vary in composition, but the following may be noted as more or less typical: 1.4 lbs. of sal soda, ½ pint of lard oil, ½ pint of soft soap, all mixed and boiled with enough water to make ten quarts. Whether emulsions or commercial cutting oils are used there is danger from spontaneous ignition when the oil is mixed with waste, rubbish, or metal chips, and this danger varies with the "drying" or "oxidizing" properties of the oil. Pure mineral oils show little if any tendency to oxidize or heat, and are therefore the least dangerous with respect to spontaneous ignition. The best cutting oil is probably pure lard oil, and the danger from this is not very great. Pure lard oil, however, is seldom if ever used nowadays for cutting, and the commercial lard oils or commercial neatsfoot oils that are extensively used exhibit far greater oxidizing activity and are dangerous. Vegetable oils exhibiting drying properties such as cotton seed oil, linseed oil, and many others are used in compounding the machine oils, and it is usually safe to assume that there is danger of spontaneous ignition and that fire will result if waste, sawdust, iron or steel chips or filings are allowed to accumulate or lie in bulk. The cardinal point for safety in a machine shop is the provision of proper receptacles for oily materials and the prompt removal of waste and waste materials. Practice in this respect is usually so good that failure to observe it may be taken as indicating poor management.

Extensive oiling systems, in which oil is circulated through pipes to automatic lathes, is collected in the pans and troughs at the lathes, and

returned through filters to the pump for recirculation, may present opportunities for severe fire due simply to the quantity of oil exposed. Such conditions in an unsprinklered plant may be very serious from the viewpoint of fire hazard. Emulsions, similarly circulated, do not present the same hazard.

Machine shop buildings after years of use frequently present the appearance of being oil soaked, and therefore give a very unfavorable impression. It is not clear that such conditions have resulted disastrously as frequently as might be feared. Apparently such conditions do not often lead to fires not susceptible to control by the operation of automatic sprinklers. The use of sawdust about machines to collect oil is not a practice that appeals to the fire prevention engineer, but if care is taken to use oils having low oxidation values, and to change the sawdust frequently, the danger may be reduced. Oil that goes on the floor is lost, and the design of machines to prevent spattering should be worth while.

Well regulated machine shops have well cut-off rooms where the oil may be filtered and reclaimed and oily waste washed and recovered. Such rooms present a potential hazard, but when well arranged and subject to good care are not often the scene of serious fires. Waste, unless very thoroughly washed and thoroughly dried before it is returned for use, is dangerous. Unless careful provision is made for the care of waste and wiping cloths it is safer to remove such material daily and burn it promptly.

Bound up with the hazards of lubricating and cutting oils, and waste, is the hazard of spontaneous heating in steel or iron chips and filings. Finely divided iron or steel will oxidize and in piles of such material the temperature may rise until combustible material in proximity is ignited. This action of heating may be encouraged by the presence of oxidizing oils. The extraction of oil from chips by any practicable method does not eliminate the hazard, and to secure safety it is necessary to so locate such material that if heating occurs no combustible material will be exposed to ignition.

To free the machine products of oil, chips and dirt, cleaning processes involving dipping in kerosene or gasoline, or spraying with these solvents are frequently used. Gasoline in dip tanks, or used with compressed air as a spray has been the important factor in many machine shop fires. The hazard is a difficult one with which to contend. By the use of dip tanks drained, covered and vented in accordance with the best practice, and equipped with foam extinguishing devices, the hazard may be much reduced. Spraying with gasoline is very hazardous, and such a process should be carefully isolated. The mixing of 50% of carbon tetrachloride with gasoline reduces the hazard, but this measure has not worked out

practically in a satisfactory manner on account of the expense, the trouble, and the difficulty of maintaining proper proportions. In many cases baths of caustic soda or similar materials in commercial preparations may produce effectively the desired results without involving fire hazards. Some of these cleaning systems depend for their effect upon an electrolytic action which goes on in the bath.

In the examination of "machine shop" plants as fire risks careful attention should be given to processes not strictly those of a machine shop, but not infrequently associated with them. Among these may be noted heat treating processes, notably hardening, used in the preparation of tools, electroplating, acetylene or oxyhydrogen welding, cutting and brazing, electric welding, forge work, lacquering, japanning, or painting.

Good construction predominates in machine shop plants, and the increasing use of fire-resistive or non-combustible materials, and of single story construction has resulted in the existence of many large properties possessing an excellent character with respect to the danger of fire. The materials present are largely non-combustible, and once the hazards of oils and waste materials are properly controlled the expectancy of serious loss by fire should be slight.

7. Cutlery and Edge Tool Manufacture.

Plants for the manufacture of table cutlery, pocket knives, axes, hatchets, chisels, auger bits, etc., manifest common characteristics as to processes and underlying equipment. Incidental processes may vary according to the particular kind or type of the product.

Raw Materials.

Steel bars or flat strips form the principal stock for edge tools. The steel is usually purchased on specifications as to its character, to insure proper strength and toughness after tempering. Special alloy steels may be used on high grade work. Handles or handle stock of wood, horn, bone, silver or celluloid, together with ferrules, paint, japan and paper or wood boxes constitute the principal incidental stocks that may be found. Grinding and polishing wheels, abrasives and polishing materials are required for the finishing processes.

Product.

As a rule, the plants engaged in manufacture of this general type specialize on definite lines of goods, and a review of such plants shows the following distinct products:—pocket knives, carving knives and forks; axes, hatchets, machetes and plow points; scythes, swords, chisels and screw drivers; auger bits, etc.

Processes.

The predominating processes are those of drop, or trip hammer forging, annealing, grinding, heat treating, polishing, fitting, finishing and packing. The blanks are first cut from the steel, heated, and shaped in a die under the blows of a drop or trip hammer. The forge shop is usually a distinct department, having the characteristics of forge shops as previously described, embracing the rough and finishing forging in two or more steps; and the annealing, hardening and tempering processes. After the blades have been formed they are ground to final shape both as to blades and hafts or shanks. The heavier part of this work is often done on large grindstones under a jet of water, but the lighter work is done with pumice or rouge on wheels built up of cloth or in some cases bristles. Handle making, according to the nature of the product, may be one of the processes. Plating or lacquering may be done.

An exception may be made to the general statement made in the preceding paragraph to the extent that cheap shears, scissors, and sometimes knives are made without forging, the parts being stamped out from the steel.

In the cutlery and edge tool industry there is a strong tendency to localization, since considerable skill and experience is required on the part of labor engaged in forging, grinding, and tempering, to secure uniform and satisfactory results. Connecticut has long been the home of many plants of this type, and while old-fashioned practices and conditions may be present in some of these factories such may be preferable to the inexperience of labor or to the speculative character of ventures found in other localities.

Hazards.

The hazards of forge shops have already been described. The old-fashioned forge shop of New England cutlery works was not infrequently a single story frame joisted building housing the hammers, the coal-fired forges and oil tempering baths. Such buildings were dark with smoke, and sparks from the hot metal flew more or less promiscuously. That plants of this kind survived the dangers of fire as well as they did must be ascribed to the carefulness of the owners and the workmen. As need for speed in production became more urgent, when oil furnaces were substituted for coal, and cheaper labor was employed, the elimination of these old plants by fire began. The forge shop of today is usually a building of non-combustible construction either all metal, or terra cotta, tile and steel.

The wet grinding process presents no serious hazard of fire, though the danger to life and limb from the bursting of a large and rapidly revolving stone is to be considered. Large grindstones are not quickly ob-

tainable in quantity, and their replacement may be an important factor in re-establishing production after a fire.

Grinding, buffing, and polishing of the metal entails the danger of spontaneous ignition of the mixture of fine particles of steel, lint, and dirt that is thrown off from the wheels. Such dirt, also, may be ignited from the sparks that are struck at the wheels.

Blower systems are almost always provided at grinding and buffing wheels in order to keep the air fairly clean for the workers. Such systems are likely to become loaded with dirt and grease unless well designed, of adequate capacity, and well cared for. Fires in them are not uncommon, and with poor arrangements may be serious. Blower pipes should be of substantial construction, be kept well supported, clean, and be clear of combustible materials. The collector should be at a point well outside the building, or well insulated from it, and be kept wet with a jet of steam or a spray of water. Of the processes in which the metal is pressed against a rapidly revolving wheel, that of buffing with rouge, beeswax, rotten stone, or other preparations is probably the most likely to give rise to fire, and if greasy material is used, its combination with the lint of the cloth wheels is dangerous. Emery wheels produce the most sparks. It is poor practice to make a single blower system so extensive as to make one serve different operations or different rooms, for by such a system a fire may be widely spread.

Handles as required may be purchased, or may be made in the cutlery plant itself. In the latter case the incidental process hazards will depend on the types and variety of handles made. Wooden handles would require woodworking processes, painting, and in some cases enamelling or japanning. Celluloid or imitation horn handle making introduces the important hazards attendant upon celluloid work, and these require isolation and special forms of protection. Unless isolated from principal areas the hazards of such celluloid work, forming, pressing, polishing, cutting, drilling, etc., may dominate the entire plant. The manufacture of wood or paper boxes and fancy cases may sometimes be a factor of considerable magnitude.

The hazards of cutlery works are usually of such a nature that sprinkler protection is effective, though this form of protection alone is at some disadvantage where there are extensive oil baths, or quantities of celluloid. Forge shops are frequently subject to extreme changes in temperature requiring the use of high test sprinkler heads on dry pipe systems. Corrosion of sprinkler equipment by gases of combustion from forge fires is also likely. Vibration due to the hammers leads sometimes to leaky pipe systems. On the whole, the use of high single story noncombustible construction without sprinklers seems advisable for this par-

ticular area, though in such a case the hazards of fuel oil and oil baths should be guarded with special care.

C. Metal Finishing Processes.

8. Finishing Metal Workers.

The manufacture of an almost numberless variety of machines, mechanical devices, and accessories, consisting largely of metal in some form, involves processes and hazards of a general group having more or less common characteristics. Plants engaged in manufacture of this kind may, for lack of a better name, be called "finishing metal workers" for in these the material receives its final forming, assembling and finishing.

Raw Materials.

The materials required vary with the particular product, but include metals in some semi-manufactured form, wood, celluloid, glass, cloth, leather, paint, japan, lacquer, boxes, packing material, and almost any other conceivable form of goods as may be required. The metals may include steel, iron, brass, copper, silver, etc., either forged, rolled, or cast, but usually in light form.

Processes.

These may include the preparation of metal in foundries, forges, rolling mills, stamping shops, grinding and polishing shops as previously described, but in more or less separate or distinct departments. The processes to be considered here, however, are those of light machine work, heat treating, welding, brazing, soldering, tinning, japanning, lacquering, enamelling, painting, polishing, plating, assembling, etc., and the more commonly associated processes using materials other than metal.

Product.

Adding machines, typewriters, clocks, mechanical toys, tools, utensils, hardware, electrical devices and numerous other contrivances of a mechanical nature require for their manufacture processes of the kind considered here, though a plant for the manufacture of one of these products may differ more or less widely from a plant manufacturing another, in some important characteristics.

The principal processes and their accompanying hazards of fire will be taken up individually.

Light Machine Work.

Light machine work consists chiefly of milling, turning, threading, drilling and other cutting operations on light metal pieces. Quantity production of more or less standard devices allows the high development of machines and tools specially suited to the work being done, so that many machines may be largely automatic in their operation. These ma-

chines prepare the materials for subsequent fitting or assembling. The fire hazard of machine rooms of this nature is usually very light and is to be measured chiefly by the care that is exercised in regard to chips, oil, and oily waste.

Heat Treatment.

Various parts of mechanical devices require the use of steel having certain qualities. Springs must be tempered, and parts subjected to impact must be hardened.

The process of "tempering" has already been described under Forge Shops. In the light metal workers the tempering operations may be of sufficient volume to result in a definite area or building being set apart for the heating furnaces, annealing ovens, oil or lead quenching baths, etc., but frequently this equipment on a small scale is found in areas occupied for other operations. In the former case, with good construction and suitable forms of protection, the hazards do not affect other areas and values materially. Small furnaces, ovens, oil baths, etc., when located with other processes often offer increased hazard due to the congestion and the presence of other combustible material about them. It is usually possible, and always desirable, to isolate a small heat treating department by means of non-combustible partitions, and to insulate the floor and ceiling so that a small process fire or oil bath fire will not quickly attack the building. The floors of such rooms should be arranged to drain to the outside of the building.

Case Hardening or Carbonizing is a heat treating process used in the preparation of important parts of many devices. It is a process which by increasing the carbon content of the surface zone of a piece of steel results in the combination of great surface hardness with strength and toughness of the interior portion. Key bars and type bars of typewriters are treated in this way. The surface hardening is accomplished by packing the metal parts in a steel box with a mixture of carbon-bearing material and some nitrogenous matter, and subjecting the whole to a high temperature in an oven. Materials used for this purpose are calcined bone, horn and hide clippings with charcoal, also various trade preparations containing barium carbonate, cyanide of potash, nitrate of potash, etc. After the hardening box has been subjected to the oven heat for a period depending on the depth of hardening desired, it is allowed to cool. The steel is then removed, reheated and quenched to give the desired temper. Sometimes a very thin hardening effect is produced by placing the hot steel in pots with ferric cyanide of potassium ("yellow prussiate of potash"), bichromate of potash, etc., by plunging into kerosene or gasoline, or by surrounding it with illuminating gas.

The hazards of case hardening depend upon the extent of the work and the manner in which it is done. Gas fired ovens of small size are

frequently used to heat the steel and the hardening boxes. Electric furnaces are now being used to an increasing extent for this purpose. Small oil tempering baths are usually found in proximity to such ovens, also sometimes baths of molten lead.

Hardening pots using cyanide, etc., heated to high temperature are liable to crack and allow the fused material to flow out and set fire to any combustible material that may be about. Hardening with kerosene and similar hydrocarbons is evidently dangerous and fortunately is not often resorted to. Hardening of spring steels is occasionally done in chambers filled with illuminating gas, and such ovens are liable to explosion.

Cyanide of potash is a poisonous material.

Where hardening processes can not be isolated from other parts of the plant it is essential that floors be either fire-resistive or well protected by metal, that proper clearances be provided about furnaces and their stacks or vents, and that oil baths be properly protected by covers, drains, foam apparatus, etc. Hardening processes may be very extensive in works where ball and roller bearings are made in quantity, as for automobiles, and in such cases the furnaces and oil baths may be predominating hazards in large areas. In such cases the use of non-combustible or fire-resistive construction is imperative.

9. Welding, Brazing, Soldering.

The joining of metal parts by fusing of surfaces in contact is accomplished in the forge shop by hammering while the metal is hot. The same method may be used on light metal parts for machines and devices, but on account of the liability of deforming the parts or otherwise injuring them, the welding is usually accomplished by electricity, by oxy-acetylene flame, or by thermit.

Electric Welding.

Electric welding is accomplished by passing a heavy electric current at low voltage through the metals to be joined. Heavy welding jobs are done by this means, but in light metal workers "spot welding" machines are frequently used under such arrangements as are required to handle the work rapidly. In these machines the work is placed between the contacts which close on it so that pressure is exerted on the joint simultaneously with the application of the current, sufficient temperature being developed to fuse the metals. With quantity production the time of contact is regulated, and the machine is semi-automatic in its operation.

The hazards of this process are those of sparks and hot metal, and of the transformers, fuses and switches used in connection with the electric power supply.

Acetylene Welding.

When oxygen and acetylene are burned together by means of a blow torch or burner the temperature of the flame is in the neighborhood of 6000° F. Such a flame is used for welding and also for cutting both light and heavy metal pieces. Oxygen and hydrogen are similarly used, and produce high temperatures.

Acetylene is sometimes generated at a machine shop plant, but it is more often purchased under pressure in steel cylinders, as are also oxygen and hydrogen. The generation of acetylene is very hazardous unless properly arranged, and very definite rules govern installations of this sort.

Oxygen, hydrogen, and acetylene under high pressure in steel cylinders involve explosion dangers, and the cylinders must be handled carefully and stored where they are not exposed to other hazards of fire. It is a mistake to allow more cylinders of compressed gas than are actually in use, inside a building where manufacturing is in progress or valuable goods are stored.

While explosions of cylinders of compressed gas occasionally occur, the principal hazard of fire is from the use of the blow torch flame. The flame will quickly ignite any combustible material with which it comes in contact and the sparks or drops of molten metal produced in the welding or cutting operations are likely to fall unnoticed and start fire. The use of acetylene flames on repair work is not infrequently found as a cause of fire. With a definite process carried on in one place, the protection of woodwork and the proper arrangement of the gas tanks and burners provided for, the hazard may be comparatively small.

AUTOGENOUS WELDING is a term applied to any form of welding in which the metal parts are joined by heat without the use of a flux or material other than the metal itself.

Thermit Welding.

Thermit welding is principally employed in repairing breaks in castings or in joining heavy pieces of metal. Thermit is a specially prepared material consisting usually of iron oxide and metallic aluminum in finely granulated form. Sometimes silicon dioxide, manganese, and nickel are added in small amounts according to the metal to be welded. The mixture may be ignited by a fairly high temperature or special flash powder, and when fired becomes molten and evolves much heat. (Temperature 5400° F.) The molten mass is poured into the joint to be welded. The action consists in the reduction of the iron oxide to free iron in molten condition by the "burning" of the aluminum. Thermit is not a particularly dangerous material, but the ignition powders provided for it are flammable.

Brazing and Soldering.

Light metal parts are very frequently joined by fusing a soft metal between them. A brazing solder consists of an alloy of copper and tin. Ordinary soldering of iron parts is done with an alloy of lead and tin or "common solder." The surfaces to be joined are cleaned with acid, and the hot solder with some borax used as a flux is heated by a soldering iron and run into the joint, or is wiped around it.

The principal hazards of soldering are those of the heating appliances used, and the heated tool or "soldering iron." Gas flames, gasoline blow torches, and electric heaters are used for heating the irons. Soldering benches on some classes of work are often extensive, and, if of wood, are usually charred where hot irons have been placed on them or other accidents have taken place. Such benches should be of metal or covered with asbestos overlaid with metal. Gasoline blow torches are dangerous and should not be furnished for heating regularly used irons at factory benches. Gas appliances should have fixed piping and ample insulation should be provided for woodwork below or near the flame. Electric irons which are arranged to heat automatically when placed on their holders have proved to be safe, but care should be taken with these to see that combustible material is kept away and that the heating circuits are shut off when the irons are not in use.

The arrangement of a soldering or brazing bench, and the care exercised by the workmen are features always deserving of attention, for fire may easily result from carelessness. Night watchmen should be instructed to examine soldering benches on their first round after the day's operations have stopped.

10. Galvanizing and Tinning.

The surface of iron may be protected against the ordinary corrosive influences of the atmosphere by a coating of zinc or tin. Hardware, pipe, metal roofing materials, etc., are extensively treated in this way and the process is frequently found in the light metal workers, notably in light hardware factories, lantern works, etc.

Hot Galvanizing.

Hot Galvanizing is done by dipping the metal which has been previously cleaned by "pickling" (see next page) into a bath of molten zinc and allowing it to remain until its temperature has reached that of the bath. Either tin, lead or aluminum may be used in alloy with the zinc.

The hazard of hot galvanizing is that of the furnace used to heat the zinc. Fuel oil or coal fires are commonly employed. Since unpleasant and corrosive fumes are evolved from the acid baths and the zinc baths, the process is usually carried on in a more or less open shed apart from other processes. Such structures should be of non-combus-

tible materials since the temperature range and the corrosive atmosphere make protection by automatic sprinkler equipment rather uncertain. Fear of steam explosions from operation of sprinklers over the baths of molten metal has little foundation, since the fine spray of water from sprinklers does not penetrate beneath the surface of the metal.

When galvanizing baths are of necessity in interior locations hoods and vents are provided, and in such cases there may be danger of fire in soot in the vent, formed from fatty materials used on the surface of the molten metal for fluxing. Both hood and furnace vents should have ample clearance from woodwork or other combustible material.

Sherardizing.

Sherardizing, or galvanizing by cementation, is a method of protecting and hardening the surface of steel by forming a surface alloy with zinc. The steel to be treated is packed in a retort with powdered zinc and zinc-oxide or charcoal, and the whole heated to a temperature slightly below the melting point of the zinc. The surface alloy of zinc which results on the steel is much more durable than the coating given by the ordinary galvanizing process. The latter is likely to give poor results if the acids used in pickling, etc., are not fully neutralized.

The hazards of sherardizing are chiefly those connected with the furnace, but there are possible hazards due to the spontaneous heating of the powdered zinc and charcoal.

Pickling.

Pickling, a process used in many departments of metal work, is simply a cleaning of metal by immersion in dilute acid, the bath sometimes being steam heated. It presents no special hazard except possibly that due to the presence and handling of carboys of sulphuric acid, which is the acid usually used.

Browning and Blueing.

"Browning" or "Barffing" is a process employed to give a dull and non-reflecting finish to the metal of gun parts, etc., an appearance sometimes referred to as "gun-metal." For military rifles it is important to obviate the glint or reflection of sunlight from the metal, which might be seen at great distance. The finish is produced by subjecting the metal to corrosive vapors from acids, corrosive sublimate, or various combinations of materials as developed by various manufacturers. Ordinarily the process involves little hazard but the wooden enclosures, sometimes steam heated, may be of considerable size, and owing to the corrosive effects, sprinklers or other fire protection devices may be maintained in or about them only with difficulty.

"Blueing" is another process of finishing metal to give a dull effect, and is employed on gun parts, typewriter parts, etc., that are exposed

to such wear that a japan or other applied coating would not remain. The finest work of this sort is done by hand, the parts being heated in a bed of bone charcoal overlaying a forge fire, and repeatedly removed and wiped with oily waste until an even and lustrous finish appears. Skilled and experienced labor is required to obtain good results. The process produces a thin surface of carbonized and oxidized metal on the steel. Hazards of the equipment are those of the forge fire and the oily waste, and particularly that of the stacks. Soot from the vaporized oil and powdered charcoal collects in the vent flues and periodic fires occur.

In blueing material in quantity, it is tumbled with charcoal or special trade preparations in rotating boxes in oil or gas fired furnaces. The effect is somewhat the same but the finish is neither so even nor so lustrous. The hazard depends on the fuel used and the furnace location and arrangement.

11. Plating.

Nickel, silver, gold, copper, brass, zinc and other metals are applied to baser materials for protection against corrosion, or, more frequently, for the sake of appearance, by the process known as electroplating. While the art and science of electroplating is complicated the process may be briefly described as that of passing an electric current from an "anode" of the metal to be deposited, through a solution of a salt of the same metal, to a "cathode" on which the deposit is to be made. The anode may be inert, and the deposit made from the solution alone.

The articles to be plated must first be very thoroughly cleaned, this work being variously done by washing or pickling in acid or caustic baths, etc. They are then hung in the solution in the plating tank in such a way as to form the cathode in the cell, being connected electrically in the circuit formed from the generator through the anodes, the solution, the cathodes and the return lead.

The current for plating is direct current of low voltage, this varying according to needs from a fraction of one volt to six volts. The power may be supplied by belt to the generator, or by a motor generator set. A rheostat is provided to allow regulation of the voltage.

The deposition of metal in the plating bath goes on for several hours, the time and the voltage determining the thickness of the plating. In order to insure an even deposit on articles of irregular shape it is frequently necessary to keep these moving in the bath.

In nickel plating, nickel ammonium sulphate is used, for silver plating a double cyanide of silver and potassium. For gold a solution of a double cyanide of gold and potassium is employed, but the article to be plated is first plated with copper. Copper plating is done from a copper sulphate or a copper cyanide solution.

Where plating is done with the precious metals the value of the plating solutions may be very considerable and subject to loss in event of fire. Plating solutions must be very carefully made to insure the success of the operations, and if they are polluted as a result of fire it may be difficult to determine the exact amount of the damage.

Hazards.

The hazard of fire in connection with the plating process is light. The vapor given off from the plating baths may, however, corrode sprinkler heads, and damage the insulation on electrical wiring. The low voltage of the plating currents render these relatively non-hazardous. Occasionally in the operation of plating, hydrogen may be evolved, and on this account as well as because of the corrosive atmospheres the ventilation of plating rooms should be good.

Detinning.

Detinning is a process involving the reverse of the plating process, and is employed to recover pure tin from tin cans and other tin plated scrap.

Tin Plating.

Tin plating should not be confused with electroplating, as the tinning is done by drawing the metal sheets through successive baths of molten tin, and squeeze rolls.

"Terne plate," such as is used in the covering of fire doors is made by the same method as is tin plate, but a mixture of one-third tin and two-thirds lead is used.

D. Painting and Enamelling Processes.

12. Painting, Enamelling and Similar Finishing.

Protective and decorative finishes in this classification applied to manufactured articles include paint, varnish, japan, lacquer and enamel. While the nature and extent of these processes influence the total hazard, there is here always the hazard incident to the presence and use of flammable liquids. Storage of flammable liquids and processes of this kind should always be located with proper consideration to other properties and values in the vicinity.

Painting.

Paint is used as a protective coating for many metal articles such as pumps, tools and agricultural implements. Where there is quantity production or large work of a rough nature the paint is applied by means of dipping, or occasionally by spraying. The work is usually dried in the air without special heat, so benzine, substitute turpentine, or other volatile thinners are ordinarily freely used. The hazards are those of

the spray booth, the dip tank, and of the storage and preparation of the paint materials. Paint rags and wiping cloths often present a decided hazard.

Varnishing.

Varnish is applied to more nicely finished material, and the work may be done by brush, by spray, or by dipping.

Varnishes are of two general classes, and include a great variety of particular preparations. The *spirit varnishes* are those which depend for hardening upon the evaporation of the solvent, and of these shellac is typical. The resin, which may be shellac, benzoin, mastic, dammar, or sandarac, is dissolved usually in alcohol, a medium which allows the resin to be spread in a uniform film. The *oil varnishes* are those which absorb oxygen from the air and harden by certain chemical changes. These are usually a compound of oil, resin and spirits of turpentine. Linseed oil, china wood oil or some other drying oil is used. The resins, or gums include kauri gum, "copal," etc.

Varnish must always be regarded as a flammable liquid, but the spirit varnishes are marked by the hazard of the volatile alcohol which flashes at ordinary temperatures, while the oil varnishes may introduce more particularly the hazard of spontaneous ignition due to the drying oils used.

Pyroxylin Varnishes are spirit varnishes in which the base is a cellulose nitrate, either gun cotton or pyroxylin, and the principal solvent is amyl acetate or "banana oil." The solvent is frequently diluted with benzol or wood alcohol. The term "lacquer" is frequently applied to the spirit varnishes, particularly the pyroxylin base varnishes, and "lacquering" as applied to a process in a light metal worker signifies the use of this material. Brassware, buttons, hardware, etc., are frequently "lacquered." Occasionally a varnish or lacquer in which the base is of cellulose acetate instead of cellulose nitrate is used, in which case the base is non-flammable, the distinction being the same as that between the "slow-burning" and the flammable types of moving-picture film. The solvents in lacquers are volatile flammable liquids, and when the lacquer or varnish is drying, flammable vapors are given off. Where heated ovens or cabinets are used for drying, the hazard may be severe. As the hardening is due to the evaporation of the solvent, steam heat is sufficient to accomplish the setting of the coat of varnish or lacquer.

Baking Japans, such as are much used on automobile bodies, fenders, etc., harden by oxidation and not chiefly by evaporation. These japans contain an oleo-resinous base with some asphaltum, and a volatile thinner. If they are applied and kept at such a temperature that the resin remains liquid until the oxidation is completed, the film will be

smooth and non-porous. A finish of great durability and beauty is obtained. The baking is done at temperatures up to 400° F. on metal.

Enamels are oil varnishes containing finely ground pigments. They are usually applied with baking processes. Such enamels should not be confused with the siliceous or vitreous enamels used in "enamelled ware," and the non-hazardous enamels of jewelry manufacture.

Japan Driers form another class of finishes. They consist of oil, resin, and a compound of lead or manganese. The latter compounds give up oxygen to effect the drying or oxidation of the oil or resin and take up more oxygen from the air, the process going on continuously and producing a very fine finish. "Driers" are not used in baking japans nor usually in spirit varnishes.

Water Japans are water suspensions, of finely divided resinous and asphaltic material. They are baked on, and are non-hazardous as no solvent is used.

The storage of all these materials, with the exception of water japan, entails certain hazards, and care should be taken to provide proper receptacles and properly isolated or shut-off storage rooms. Storage rooms should be well ventilated and free from those sources of ignition to which flammable vapors are sensitive. Material of this sort in quantity should not be exposed more than is necessary in the manufacturing operations.

The application and further treatment of these finishes involves hazards of three general classes which are so important as to deserve individual treatment, namely dipping, spraying, and heating or baking, and these subjects are taken up in detail under the headings which follow.

13. Dipping.

Where uniform articles are produced in quantity, coatings of paint, varnish, lacquer, or japan, etc., are applied economically by dipping or submerging the articles in a tank of the coating material. Dipping operations in a metal worker affect the total hazard materially, the degree of the hazard depending on a number of factors.

The chance of fire occurring depends in an important degree on the flash point of the flammable volatile thinners used in the liquid in the dip tank, the amount of evaporation that occurs from the liquid surfaces and from the freshly dipped articles, and upon the behavior of the vapors produced.

The hazard may be minimized by the use of kerosene, turpentine, or other high flash point thinners instead of naphtha, benzine or other highly volatile liquids. The amount of evaporation may be somewhat reduced by keeping liquid surfaces covered in so far as possible, but as evaporation of the thinner or solvent is an essential part of the process other measures must be resorted to in order to minimize the hazard.

It is essential that dipping rooms be at all times so ventilated that dangerous vapor-and-air mixtures will not accumulate. Certain vapors, such as those from gasoline or benzine, are heavy and do not diffuse rapidly. Where such may be present, constantly open outlets at the floor level should be provided. With lighter vapors, or hot vapors, ceiling vents should be provided. Artificial ventilation systems designed to pick up vapors from near the points where they are evolved, and to keep the entire area well ventilated are frequently necessary. Dipping rooms should always be above surrounding grade, have ample window area, and preferably, a ventilating monitor in the roof.

Assuming the ventilation of the dip room to be properly cared for, it still remains necessary to remove from the dip room all those causes for ignition of vapors which may be discoverable. Open flames of any sort, exposed electric switches, fuses, lights, and drop cords should be eliminated, and a grounding system provided to prevent static electric sparks. The entire electric equipment should be of the vapor proof type.

Fire Protection for Dipping Rooms.

Fire protection in dipping rooms requires special consideration since fires involving considerable quantities of flammable liquids or freshly dipped articles are frequently difficult to subdue by ordinary measures.

A fire in a dip tank may be easily smothered if a tight, substantial cover can be closed upon the tank promptly. The conditions of operation frequently preclude this and it is important that either bottom or overflow drains, properly trapped, be provided to carry the liquid to some safe point outside. Water from sprinklers or hose streams may overflow the dip tanks and spread fire about if ample provision for drainage is not made. It is important that the dip tanks themselves be substantially constructed and well supported, lest accident or fire cause the escape of the liquid contents.

As fires in dipping rooms are frequently in the nature of flash fires, it is essential that the water supplies to automatic sprinklers be sufficient to produce good discharge from all the sprinklers in the area. Automatic sprinklers so supplied will usually take care of any fire outside the dip tanks themselves, and may even hold down the fire in the tanks provided that they do not overflow. For the prompt extinguishment of fire in the dip tanks several special measures are available, all based on the smothering of the fire. Carbon tetrachloride may sometimes be effectively used if the gases from it may be confined in a receptacle or enclosure, but this material has disadvantages due to the irritating or possibly poisonous gases that are produced. Mixtures of sawdust and bicarbonate of soda, applied by scoops or by automatic dumping, will float on the liquid surface and produce a smothering effect. The modern foam extinguishers, ar-

ranged for automatic or manual application are probably the most effective agents for handling such fires now available.

The nature of the dipping room hazard is such that the area should be cut off or effectively isolated from other parts of the plant by means of fire-resistive partitions. Only by such isolation can fires be efficiently handled and widespread damage averted. Care should be taken not to locate dipping rooms above others in which are goods susceptible to water damage, unless the intervening floor be waterproof.

Definite rules for the protection of dip tanks have been prepared by the National Fire Protection Association, and these should be consulted for information and instruction.

14. Spraying.

The application of paint, varnish, enamel, etc., to irregular articles requiring a nice finish is economically accomplished by means of the air brush. The mechanical device to produce the spray of paint presents no particular hazard, but the general arrangements in the spray painting room are such that a marked hazard is present. A supply of paint in an elevated container or under air pressure, a compressed air system, tubing, and the spray gun are necessary to produce the spray, and usually a hood with vent leading to outside the building is provided to confine the spray. An electric heater is frequently provided to warm the paint or enamel, the heater being located between the paint supply and the spray gun.

The use of the spray produces an atmosphere of flammable vapor while the work is in progress. Freshly coated articles are present in and about the spray booths. Waste paint or other spray accumulates over the interior of the booths and in the ventilating pipes. Under such conditions a flash fire may readily occur and be followed by a rather stubborn and smoky fire in the exposed material.

Spray painting rooms should be in a detached small building or be shut off or cut off from other rooms. The general ventilation should be effective. The entire electrical equipment should be of the vapor proof type, and open flames should be rigidly excluded. Fires in spray booths or the ducts leading therefrom are not infrequent. The interior of booths should be kept clean, and the booths themselves should be of substantial metal construction. It is preferable to locate spray booths against an exterior wall in order that natural light may be available and direct ventilation to the outer air secured.

The vent from each booth should be independent of others, and be as short and direct as possible and be brushed clean of combustible material at frequent intervals. Fans in the vent ducts frequently cause fires unless they are arranged with outside bearings, good clearance, soft metal

Courtesy Gehnrich Oven Co. (Member N. F. P. A.).

A spray booth at right. The oven at the left is of the type used for small parts.

blades, and other precautions necessary in the moving of flammable vapors.

The main supply of paints, etc., should not be kept in the spraying room. The containers should be kept covered, be of substantial construction and be securely supported.

Spray booths, except those of very small size, should be equipped with sprinklers inside. Foam and soda acid extinguishers should be provided in generous number, and located near the door or in some other convenient place where they will be accessible without too close exposure to a fire.

The measures necessary for the proper protection of spray rooms have been studied by the N. F. P. A. Committee on Manufacturing Risks and Special Hazards and are covered by the published regulations.

15. Ovens and Dryers.

Following the application of paint, lacquer, japan, or other such material to manufactured articles, the coating is dried, set, or baked on by the application of heat, the temperature being determined by the materials used and the character of the finish required. In addition to the decorative or protective coatings, the application of insulating compounds, varnish, etc., to armatures, coils, etc., requires processes of a similar nature.

High temperatures employed in manufacturing operations always involve a hazard, and the use of high temperatures in ovens treating goods coated with flammable materials give rise to serious hazards due to the combination of the heating arrangements, the combustible material and the long continued heat. Some ovens, such as those used for core baking in foundries, or others in which the goods treated are non-flammable may present only those hazards due to the furnace or other heating arrangements.

The hazard of ovens of the type here considered, depends upon the temperature carried, the nature of the vapors or materials that may be present in them, and upon the general construction and arrangement. The effect of such equipment on the total hazard depends on the location with respect to other materials and processes and the surrounding construction.

Ovens, in general, should be isolated from other hazardous areas or damageable goods, by means of fire-resistive walls or partitions. They should be of non-combustible construction. The construction of ovens to secure a low thermal capacity and a small loss of heat through the walls is a matter of very considerable importance as affecting the economies of production and modern ovens are usually carefully built of insulating material encased in metal and supported on steel. Brick or terra cotta ovens may be required for very high temperatures, but they have the disadvantage of large thermal capacity, requiring much heat to raise the temperature. Wood or fibre board should never be used in oven construction, even in steam heated ovens.

Ovens may be classified as direct heated, semi-indirect heated or indirect heated ovens. It is obvious that any oven baking or heating material having a combustible coating, such as japan, is dangerous if the firing or combustion chamber is in direct communication with the baking compartment. If the fire is in an entirely separate compartment or the heat is by steam, the danger is much less.

Steam heated ovens are properly indirect heated ovens. Some ovens are "semi-indirect" in that while the firing chamber is shut off, the products of combustion finally find their way into the baking compartment.

Ovens may be classified also according to the method of heating. Coal or coke, oil, gas, steam and electricity are employed with various arrangements for each.

Coal fired ovens may be quite satisfactory if the combustion chamber is tightly and securely shut off from the baking chamber, and there is no hot surface exposed to dripping from the goods being treated. The fuel arrangements, ash removal, insulation of the fire box and stack must all be proper, and the fire box must not be in an area with other

combustible material. Frequent faults in old ovens of this sort included direct communication of fire box and oven, light smoke flues passing through the oven, and poor firing arrangements or practice.

Oil burners have been extensively used for oven heating. Much the same considerations apply here as with the coal fires. Fuel oil itself is attended by considerable hazard in use, and safety may only be secured by following the well established rules. Oil burners for ovens should not be installed on wooden floors nor preferably in any area not fire-resistive and not shut off from other parts of the plant.

Special independent oil fired units for heating air to be forced through ovens have been developed, and these combine a very considerable economy with a degree of safety only obtainable with indirect heating and the isolation of the firing unit.

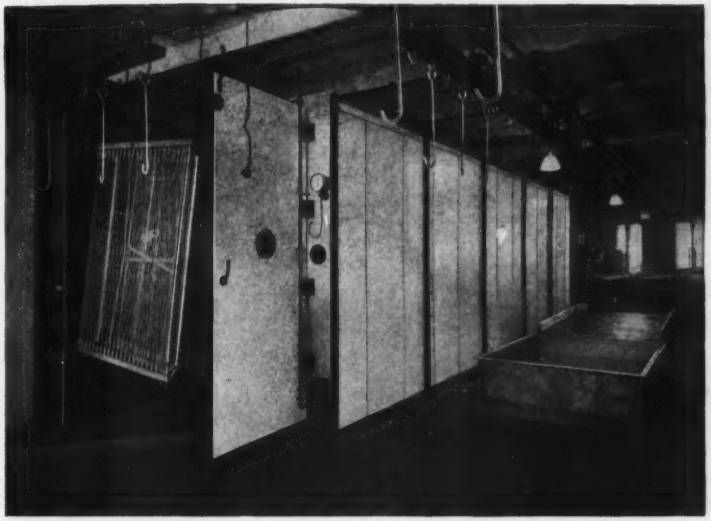
Many oil fired ovens are unsatisfactory from a safety standpoint due to the presence of red hot combustion chambers or pipes subject to drip in the oven, or to the firing being done in proximity with the oven doors. This is particularly true of "home-made" ovens.

Gas is used in direct, indirect, and semi-indirect arrangement. As previously pointed out direct firing is objectionable where flammable vapors may be present. If the gas is kept constantly burning it may have the effect of burning up and removing the vapors as fast as they are formed. With intermittent operations however, trouble is almost sure to result sooner or later. Indirect gas firing may be quite satisfactory, and it is much employed. It is important however, that the drip from materials in the oven does not fall on superheated surfaces, and that the gas flames and pilot lights be distant from dip tanks and other sources of dangerous vapor.

Semi-indirect gas firing isolates the actual flame but allows the products of combustion to flow into the oven chamber. The peculiar disadvantage of this system is that if there is a leakage of unburned gas, the large oven chamber may be filled with it and a very severe explosion follow its ignition. While various safeguards are provided to prevent this, a number of serious explosions have occurred with this type.

Steam heated ovens usually present a relatively mild hazard if the steam pipes are at all times properly insulated and do not accumulate drip. The temperature range is usually lower than with other types of heating.

Electrically heated ovens are extensively used on account of ease of operation and cleanliness, though where the heat requirements are large and constant the expense may be an important factor. Electric resistance heating units which are incandescent may be a constant source of danger as they are exposed to flammable vapors. Loose or broken contacts, also, may cause high temperature arcs to occur. Heating units should be so located that they will not receive drip.



Courtesy Gehnrich Oven Co. (Member N. F. P. A.).

Oven with overhead conveyor for handling objects baked. At the right is a dip tank with its drain board.

In the examination of ovens careful attention should be given to the heating system and particularly to the insulation of furnaces and stacks from combustible floors, walls and ceilings.

Whatever the method of heating, the danger from flammable vapors in the oven is always to be considered. Ventilation of the oven chamber is important and should be positive; vents at high and low levels are desirable in order that vapors may not become pocketed.

The danger in event of fire or explosion is dependent to an extent on the size of the oven. Fires in ovens are frequently in the nature of explosions and the larger the oven, the greater is the effect likely to be.

The general character of the hazard indicates the desirability of placing ovens only in fire-resistive buildings, and isolating them from areas otherwise occupied.

Recent developments in quantity production have lead to the extensive use of continuous processes for dipping and baking materials on conveyor apparatus. This brings the dip tank and oven hazards into conjunction, and with the large dip tanks and large enclosures frequently used, the danger is severe, not only from fire but from explosion. While the hazard of such devices may be reduced by the use of the least hazardous of the heating systems, and by the application of automatic foam extinguishing devices to protect the dip tank, there still remains an ex-

plosion hazard in the oven chamber which cannot well be avoided and which may operate to destroy the protection systems in the area about it. The economy of such equipments in mass production is unquestioned but the liability of widespread damage and serious interruption of production should be considered.

Authoritative rules governing construction and protection of ovens, particularly japan ovens, have been prepared by the N. F. P. A. Committee on Manufacturing Risks and Special Hazards and should be consulted for the details of the necessary precautions.

Metal Working Industries—Fire Record.

The following fire record on the metal working industries has been prepared by the Executive Office from the N. F. P. A. Fire Record files to accompany the preceding article by Mr. Milne on the hazards of metal working processes. This record should be read in connection with the preceding article which explains the relation of the several processes and the nature of the hazards involved.

This classification, involving a total of 6522 fires, covers a larger number of fires than any similar record previously published in the QUARTERLY. Because of the comprehensive nature of the tabulation and the lack of space in this QUARTERLY, this record is necessarily presented in considerably less detail than similar compilations published in previous issues. This is especially true as regards the summaries of typical fires, which because of lack of space have been considerably curtailed.

The fire record files of the N. F. P. A. are necessarily classified by occupancy rather than by process. Mr. Milne's article treats the subject by process, and in order to prepare a fire record similarly classified it has been necessary to make a temporary rearrangement of all the fire reports on metal working industries. The various classes of occupancy included in this record, which it will be noted include some classes not ordinarily thought of as "metal workers," but actually presenting very similar hazards, are as follows:

Occupancy Classification	Total No. of Fires
Class A—Converting Plants	89
Class B—Rolling, Wire and Tube Works	274
Class C—Structural Iron Works	147
Class D—Forge Shops	151
Class E—Foundries	846
Class F—Machine Shops	629
Class G—Stamping and Sheet Metal Works	320
Class H†—Light Metal Workers	890
Class I††—Heavy Metal Workers	1038
Class J—Agricultural Implements	168
Class K—Automobile and Bicycle Factories	527

Class L—Bolt and Nut Factories	55
Class M—Electrical Appliances	570
Class N—Metal Bed Factories	114
Class O—Stove Works	162
Class P†††—Miscellaneous Metal Workers	542

† Light Metal Workers include cutlery, toys, hardware, nails, pins, light fixtures, tools, small machines, instruments, automobile accessories, taps, dies, pins, screws, etc.

†† Heavy Metal Workers include pumps, engines and other heavy machinery, locomotives, printing presses, guns, looms, safes, cars, scales, etc.

††† Miscellaneous Metal Workers include metal workers where there is lack of detailed information as to class.

The relation between special and common hazard causes of fire in the metal working industries is shown by the following table.

Fires in Metal Working Industries—Summary of Causes.

Number of Fires.

Class of Occupancy	Common Causes	Special Hazard Causes	Total Known Causes	Unknown Causes	Total
A	37	34	71	18	89
B	109	101	210	64	274
C	60	47	107	40	147
D	35	94	129	22	151
E	225	454	679	167	846
F	323	162	485	144	629
G	139	112	251	69	320
H	403	318	721	169	890
I	483	387	870	168	1038
J	71	62	133	35	168
K	278	182	460	67	527
L	28	15	43	12	55
M	312	173	485	85	570
N	48	45	93	21	114
O	65	60	125	37	162
P	255	168	423	119	542
Total	2871	2414	5285	1237	6522

In studying the common causes of fires this classification has been retained as common hazards do not depend on process but may be found in all types of factory. The common cause record is tabulated on the next page. This table of common causes perhaps includes some fires which might be classified as special hazards. For the purposes of preparing this record, however, only the hazards inherent in and peculiar to the special metal working processes have been classed as special hazards. All other hazards have been classed as common. The treatment of fuel oil fires will serve to explain the method of classification. In the table of common hazard fires will be noted 74 fires due to defective fuel oil equipments. In other tables there will be found fires involving fuel oil heated forges, ovens, etc. The fuel oil fires, where the equipment was used in connection with a power plant, or in some situation common

Common Causes of Fires in Metal Working Industries.

No. of Fires by Class of Occupancy.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
Heating	7	14	8	3	35	37	17	42	48	9	26	6	51	5	8	37	353
Power	3	6	3	3	24	33	13	45	55	9	31	3	60	3	6	25	322
Matches or Smoking		15	7	2	12	41	20	78	50	2	14		39	2	4	31	317
Oily Material	2	10	7	4	11	27	18	39	48	5	24	5	24	9	9	23	265
Electrical	9	10	4	3	17	26	6	21	47	6	31		20	4	4	11	219
Boiler	2	10	3	3	10	26	7	25	28	11	13		11	2	1	9	161
Rubbish or Sweepings		4	1	1	5	20	16	27	12		15		16	5	5	19	146
Flammable Liquids	2	2			6	12	5	16	13	2	42		15	1	5	13	134
Exposure	1	6	3		18	22	9	8	20	1	2	3	6	3	2	16	120
Locomotive Sparks	6	7	5	2	29	10	3	6	19	4	5		3	2	8	9	118
Lighting	2	5	3	1	4	9	6	20	17	5	14		11	1	2	7	107
Lightning		4	5		9	12	7	19	19	2	8	1	4			8	98
Chimney or Flue	1	5	1	4	6	5	1	2	22	4	11	2	8	2	3	7	84
Fuel Oil System		2	1		8	8	2	10	27	1	4	4	3			4	74
Spontaneous Ignition of Coal		2	1 2	1	4 4	11 8	3	9 14	8 17	1 1	10 4	2	18 4	1	1 2	8 10	73 73
Incendiary		4	5	3	7	6	2	8	8	1	3		5	4	2	7	65
Thawing Frozen Pipes				2		2			5	2	2		3			1	17
Miscellaneous	2	3	1	3	16	8	4	14	20	5	19	2	11	4	3	10	125
Total	37	109	60	35	225	323	139	403	483	71	278	28	312	48	65	255	2871

to all processes, have been classed as common hazard, but where the equipment was used especially for forging, fires have been placed in the forging process tabulation.

The two following tables, Effect of Sprinklers and Analysis of Loss, have been prepared according to occupancy. These include only the fires due to common and unknown causes, the special hazard fires being tabulated according to process in the subsequent tables. The table on sprinkler efficiency shows that in 95.2% of all fires the sprinklers extinguished the fire or held it in check, a record that compares with the general sprinkler efficiency in all occupancies of 95.7%.

Effect of Sprinklers.

Class—	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total
	No.	%	No.	%	No.	%	No.	%	
A—Converting Plants	3	30.0	5	50.0	8	80.0	2	20.0	10
B—Rolling, Wire and Tube	42	59.2	24	33.8	66	93.0	5	7.0	71
C—Structural Iron	16	59.3	8	29.6	24	88.9	3	11.1	27
D—Forge Shops	19	76.0	5	20.0	24	96.0	1	4.0	25
E—Foundries	75	54.7	54	39.4	129	94.1	8	5.9	137
F—Machine Shops	170	68.0	67	26.8	237	94.8	13	5.2	250
G—Stamping and Sheet Metal	100	63.0	46	28.9	146	91.9	13	8.1	159
H—Light Metal	324	69.2	127	27.2	451	96.4	17	3.6	468
I—Heavy Metal	242	61.3	131	33.2	373	94.5	22	5.5	395
J—Agricultural Implements	48	57.2	31	36.9	79	94.1	5	5.9	84
K—Auto and Bicycle	150	60.3	86	34.6	236	94.9	13	5.1	249
L—Bolt and Nut	17	63.0	10	37.0	27	100.0	0	0	27
M—Electrical Appliances	213	70.1	83	27.3	296	97.4	8	2.6	304
N—Metal Bed	39	68.5	15	26.4	54	94.9	3	5.1	57
O—Stove Works	37	68.5	15	27.8	52	96.3	2	3.7	54
P—Miscellaneous M. W.	198	68.1	82	28.2	280	96.3	11	3.7	291
Total	1693	64.9	789	30.3	2482	95.2	126	4.8	2608

Analysis of Loss.

Class—	Number of Fires			Total
	Small Loss†	Large Loss†	No Data	
A—Converting Plants	31	19	5	55
B—Rolling, Wire and Tube	113	46	14	173
C—Structural Iron	61	28	11	100
D—Forge Shops	33	21	3	57
E—Foundries	238	116	38	392
F—Machine Shops	333	108	26	467
G—Stamping and Sheet Metal	137	61	10	208
H—Light Metal	443	104	25	572
I—Heavy Metal	516	116	19	651
J—Agricultural Implements	66	38	2	106
K—Auto and Bicycle	303	35	7	345
L—Bolt and Nut	28	11	1	40
M—Electrical Appliances	334	47	16	397
N—Metal Bed	48	17	4	69
O—Stove Works	59	40	3	102
P—Miscellaneous M. W.	300	49	25	374
Total	3043	856	209	4108

†Small loss fires are those causing damage under $5000; large loss over $5000.

The table on Analysis of Loss because of the necessary limitations of this record has not been separated into sprinklered and unsprinklered fires (but this segregation has been made in the subsequent process hazard tabulations). The relatively small proportion of large loss fires may be attributed to the fact that more than half the reports used in preparing this table were on fires in sprinklered properties.

Fires caused by special hazards inherent in metal working processes have been classified by process as shown in the table "Number of Fires by Class of Occupancy." A study of this table shows the predominating process hazards of the various metal working occupancies. For example, the table indicates that the finishing process constitutes the chief hazard in the automobile industry and that the foundry is the principal hazard of the heavy metal workers. Foundry, forging and finishing process fires make up the bulk of the 2414 special hazard fires tabulated.

Number of Fires by Class of Occupancy.

Process	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
Converting	27	4			6				2			1					40
Rolling	3	55							1							1	60
Forging	3	5	6	92	4	55	2	75	93	25	35	6	1		1	45	448
Casting	1	1	4		433	16	1	28	155	13	13		16	7	29	7	724
Structural Iron Working			29		2	1			19	1	1		1				54
Machining		2	2			51	1	19	11	2	9	7	1	1		4	110
Stamping						1	22						4				27
Grinding and Polishing		1	1		1	3	10	31	13	2	3		9	1	5	19	99
Assembling		11	1	1	7	13	30	41	36	2	19	1	34	2	1	25	224
Finishing		22	4	1	1	22	46	124	57	17	102		107	34	24	67	628
Total	34	101	47	94	454	162	112	318	387	62	182	15	173	45	60	168	2414

Converting Processes.

Blast Furnaces.

Fifteen special hazard fires are recorded in connection with blast furnace operation. A brief summary of the causes of these fires follows:

SLAG FIRES. H-11257. A slag ladle "exploded" and set a nearby frame building on fire.

H-13354. Slag dumped into a pit containing water caused an explosion.

H-13029. Molten slag dropped into water. The presence of iron in the slag caused an explosion which threw the molten material a distance of 200 feet, igniting a frame building. The loss was about $30,000.

H-16071. Molten slag was being carried off in a tip car. The king bolt of the car broke and the car tipped over. The slag ignited a frame building. A switchman on the car was burned to death. The building was destroyed.

HOT METAL. H-5391. A ladle containing 100 tons of steel was overturned at the blast furnace. The loss was small.

H-11526. The blast furnace lining broke and molten iron ran out.

H-15336. Molten metal splashed through a window into the oil house which caught fire.

H-16427. The lining of a blast furnace gave way and allowed molten metal to flow out on the floor. The loss was large.

HEAT FROM FURNACE. H-2682. Heat from a blast furnace ignited the roof. The loss was $10,000.

S-21041. Sparks from a blast furnace ignited the roof house. The loss was $560.

H-15369. A spark from the blast furnace ignited the wooden roof. The loss was $1,200.

ORE. H-15366. Heat from a coke burning salamander ignited the wooden ore bins. The loss was small.

H-17693. A salamander used under the ore storage bin to thaw out frozen ore was neglected and wooden bin ignited. The loss was $5,000.

H-16567. Hot ore from a sintering furnace ignited the woodwork of a metal lined dust flue. The frame, metal clad, building housing the sintering process was destroyed. The loss was large.

SAND DRIER. S-35676. A gas burning sand drier became overheated and the hot vent pipe ignited the roof. The loss was $125.

Puddling Furnaces.

Six special hazard fires are reported as due to puddling furnaces. In five of these fires heat or sparks from the furnace ignited surrounding combustible material. The losses in four cases were small and in one case the loss was $22,000.

In one fire the hopper to the furnace was being filled with coal. The coal overflowed through a measuring hole and was ignited by flame issuing from the sides of the furnace below the hopper. The loss was $350.

Steel Converters.

Special hazard fires in steel converting plants are recorded as follows:

Cause	No. of Fires
Hot metal	5
Failure of furnace	4
Sparks from furnace	3
Oil supply pipes broken	3
Gas producer fire	2
Hot ingots	2
Total	19

In only two of these fires was the loss larger than $5,000. Details as to the causes of some of these fires are given below.

H-18196. Iron ore was being added to melted steel in an open hearth furnace. The metal boiled over and the intense heat caused the plank roof to ignite.

H-16139. A 20-ton ladle filled from the open hearth furnace was being carried to the moulds when the bale broke and dropped the ladle. Molten steel splashed up and ignited the roof. The loss was large.

H-7320. One of the iron bands around an open hearth furnace broke just as the metal was about to be drawn off. This caused the

arched top of the furnace to drop into the molten metal. The intense heat given off ignited the wood trim of the building.

H-15916. A furnace which burned producer gas backfired and emitted a blast of flame which set fire to the frame roof of the building.

H-13461. The frame wall of the building was ignited by hot ingots placed near it.

Rolling.

Fire Causes.

Cause of Fire	No. of Fires	
ANNEALING FURNACE		
Heat from furnace ignited combustible material	11	
Sparks from furnace	6	
Gas explosion	1	
	—	18
FUEL OIL		
Supply pipe broke	5	
Excessive supply of oil	2	
Hot "threading up hook" ignited oil	2	
Defective shut-off valve	1	
Workman opened air valve while cap of filling pipe was off	1	
Exact cause unknown	2	
	—	13
Sparks or hot scale from rolls		11
PIPE DIPPING		
Asphaltum paint ignited	3	
Tallow ignited	1	
Tar boiled over	1	
	—	5
PRODUCER GAS		
Flame ignited combustibles	2	
Hot soot	2	
	—	4
Hot metal		3
Tempering oil overheated		1
Gas heater ignited pot of pitch		1
Spontaneous ignition of charcoal		1
Spark from emery wheel		1
Spark from hot saw		1
Spark ignited olive oil		1
Total		60

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Large Loss	2	10	12
Small Loss	21	23	44
No Data	..	4	4
Total	23	37	60

Interesting Causes of Rolling Mill Fires.

H-18468. The fireman was heating up an annealing furnace which was fired by a gravity feed fuel oil system. The oil flooded and backfired, setting fire to a frame wall.

H-14199. While the cap of the filling pipe was off, a workman opened the air valve of the fuel oil system, causing the oil to be forced out of the tank. The oil ignited from a hot fuel oil forge. The loss was $200.

H-16586. Scale from a hot rolling mill fell upon the floor near a bearing. Grease from the bearing that dropped on the floor was ignited by the hot scale. The loss was small.

H-6366. In this plant metal pipes were heated in a coke fire and placed while hot in a tank containing asphaltum paint thinned with benzine. The paint was ignited by an overheated pipe.

H-19516. Pipe was dipped in hot tar to form a rust resisting coating. The tar became overheated and boiled over. The loss was $21,000.

H-17992. Employees were letting soot out of producer gas dust collector. Hot soot mixed with gas blew out of the collector and ignited. The flames burned the roof trusses. The loss was $200.

H-12852. A load of hot steel billets was dropped from a crane and ignited a yard shed.

Forging.

Fire Causes.

Cause of Fire	No. of Fires
FORGE	
Sparks from forge	104
Sparks from hammer	19
Overheated forge	6
Hot ashes from forge	5
Flammable liquids ignited from forge	4
	—138
HEATING FURNACE	
Sparks from furnace	23
Heat ignited surrounding combustibles	5
Overheated furnace	4
Furnace wall failed	1
Slag ignited some lumber	1
	— 34
FUEL OIL	
Supply pipe broken	32
Clogged fuel oil system	7
Oil overflowed	17
Leak from pipes	10
Overheated fuel oil furnace	7
Backfire	7
Miscellaneous	13
	— 93

ANNEALING		
Annealing furnace ignited surrounding combustible material	13	
Sparks from annealing furnace	8	
Hot metal	4	
Hot carbon	2	
Miscellaneous	6	
		— 33
HARDENING		
Furnace overheated	19	
Overheated quenching oil	19	
Leaking oil	3	
Oil overflowed	3	
Hot sodium nitrate	3	
Fish oil ignited	3	
Cyanide explosion	2	
Miscellaneous	9	
		— 61
TEMPERING		
Oil overheated or boiled over	28	
Hot metal ignited oil	25	
Heat or sparks from furnace	14	
Oil leak around furnace	4	
Miscellaneous	4	
		— 75
Hot metal ignited woodwork		3
Miscellaneous		11
Total forge fires		448

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Large Loss	9	41	50
Small Loss	274	107	381
No Data	2	15	17
	285	163	448

Interesting Causes of Forge Shop Fires.

H-8204. A spark from an oil forge (equipped with a hood) lodged on some roof timbers covered with dust and oil. The timbers ignited and the resulting fire caused a loss of over $18,000.

H-19875. A spark of hot metal from a forge hammer flew into a steel locker containing clothing. It smouldered until night and finally the clothing burst into flame. The loss was $150.

H-6137. A shaft to be reforged was being heated in the furnace. The shaft projected out from each end of furnace and during the turning of the shaft, the brick work of the furnace at one end fell out. Flames from the furnace ignited the roof. The loss was $2,200.

H-19387. A coupling in the fuel oil line to the furnace was broken and when an employee started the oil pumps in the morning the oil

leaked out on the floor. This oil was ignited when the man brought in a torch to start the burners. The loss was $3,500.

S-15042. Metal parts being heated in an annealing furnace had become so hot that when they were drawn from the furnace and immersed in an oil bath, the oil ignited. The loss was $7,000.

S-24239. While the plant was closed down rain leaked through the roof into a hardening oil tank, and settled to the bottom of the tank. When the tank was heated up, the water boiled and the oil boiled over. The loss was $6,000.

S-25206. An explosion occurred when the intense heat evolved in a process of oxidizing or hardening in a compound of sodium nitrate and caustic soda fractured the kettle. The loss was $2,200.

H-479. An ember from the forge fire flew into a tank of whale oil used to harden saws. The resulting fire caused a loss of $5,800.

S-29253. A basket of cold steel springs ran off from an overhead track and dropped into a pot containing liquid salt. An explosion followed causing a loss of $650.

S-33611. This fire was caused by a bit of hot scale dropping from a piece of bar steel when it was being removed from a fuel oil heated tempering furnace and igniting a small quantity of oil on the floor. The loss was over $40,000.

H-1600. Some red hot irons were placed near an iron covered partition. The heat ignited wood behind this partition. The loss was $30,000.

Foundries.

Fire Causes.

Cause of Fire	No. of Fires	
CUPOLA		
Sparks from cupola	329	
Heat ignited surrounding combustibles	39	
Sparks or hot metal from dumping cupola	17	
Hot slag	12	
Miscellaneous	3	
		400
CORE OVENS		
Heat ignited surrounding combustibles	83	
Sparks from oven	22	
Soot in flues of oven ignited	10	
Core oil ignited	4	
Hot core ignited woodwork	2	
Miscellaneous	7	
		128
MELTING FURNACES		
Sparks from furnace	9	
Furnace broke down	8	
Oil supply pipe broken	8	
Furnace ignited surrounding combustibles	5	
		30

POURING		
Hot metal splashed over while pouring, or sparks from molten metal	79	
Hot castings ignited woodwork	17	
Mould exploded	4	
Flashes ignited by hot metal or sparks	30	
		130
MISCELLANEOUS		
Ignition of tar or asphaltum dip	9	
Spontaneous ignition of charcoal	8	
Annealing furnace	7	
Sand drying oven	3	
Sand blasting	2	
Spark from grinder	2	
Miscellaneous	5	
		36
Total Foundry Fires		724

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	274	335	609
Large Loss	12	80	92
No Data	2	21	23
	288	436	724

A report on foundry processes and hazards and a comprehensive fire record of 475 foundry fires appeared in the July, 1915, QUARTERLY (Vol. 9, No. 1, p. 76).

Structural Iron Works.

Fire Causes.

Cause of Fire	No. of Fires	
FUEL OIL		
Broken pipe	12	
Oil overflowed or blew out	12	
		24
HOT RIVETS		13
WELDING		
Sparks from acetylene torch	4	
Miscellaneous	4	
		8
SPARKS FROM FURNACE		6
MISCELLANEOUS		3
		54

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	21	17	38
Large Loss	0	11	11
No Data	1	4	5
	22	32	54

Interesting Causes of Structural Shop Fires.

S-35464. A kerosene oil furnace used for heating rivets for fire escapes burst into flames due to the rupture of a tank container and piping on account of excessive air pressure in the tank. The loss was $500.

H-8248. A heavily loaded truck in the car erecting shop collided with the crude oil supply pipe, breaking the pipe close to the ground near the riveting furnace. The oil was ignited by the heat from the furnace. The loss was $22,000.

S-26096. A bar of steel was being sawed with a hack saw. A kerosene oil torch was in use nearby. One end of the bar fell on the torch and broke off a fitting. The kerosene was forced out and ignited. The loss was $800.

S-35335. While employees were heating rivets in a gas forge a hot rivet fell through a knot hole in the floor into a dip tank in the basement.

H-18849. A short circuit of electric wiring near an air compressor ignited oily material nearby. The fire caused the explosion of a kerosene oil barrel. The loss was $56,000.

Stamping and Sheet Metal.

Fire Causes.

Cause of Fire	No. of Fires	
Annealing ovens	3	
Quenching oil	4	
Tallow or rosin overheated	4	
Flammable liquids	5	
Metal fed too close through paint rolls ignited paint	9	
Overloaded floor	1	
Overheated drying oven	1	
Total	—	27

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	20	3	23
Large Loss	1	2	3
No Data	1	0	1
	22	5	27

Interesting Causes of Stamping and Sheet Metal Fires.

S-13247. A mixture of rosin and linseed oil boiled over in the mixing kettle. The loss was small.

S-32727. Fire occurred in a tin can factory in an agitating machine filled with a rubber and benzol compound. The cause was probably a spark struck by the employee who was pouring the compound into the agitator. The loss was $1,500.

S-26662. An employee upset a kerosene blow torch of about 15 gallons capacity which was being used to heat sheet metal in process of bending. The loss was small.

S-7957. Power driven rolls were used to paint sheet iron. The lower roll dipped into an open tank containing a mixture of oxide of lead, boiled oil and benzine. The benzine vapor was ignited by a torch. The loss was small.

H-14026. This fire was started in the cellar by a wood burning furnace located directly under a large stamping press. The floor supports weakened and let the press fall into the cellar. The fire spread rapidly and caused a large loss.

Machine Shops.

Fire Causes.

Cause of Fire	No. of Fires	
SPONTANEOUS IGNITION		
Oily waste	25	
Oily chips and filings	7	
Linseed oil	1	
	—	33
HEAT TREATING		
Annealing	1	
Tempering	22	
Hardening	4	
Heat from lead melting pot	3	
	—	30
FLAMMABLE LIQUIDS		
Gasoline	9	
Benzine	6	
Oil	2	
Kerosene	1	
	—	18
SPARKS OR FRICTION FROM METAL CUTTING		10
IGNITION OF ASPHALTUM, ROSIN, OR PITCH		8
MISCELLANEOUS		11
Total		110

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	77	17	94
Large Loss	1	11	12
No Data	1	3	4
	31	79	110

Interesting Causes of Machine Shop Fires.

H-11534. A hot tool which was being immersed in a bath of tempering oil slipped from the tongs of the workman and struck the fuel oil feed pipe. Oil leaked from the broken pipe and ignited.

H-3601. Benzine used for cleaning metal parts was kept in open pans. Heat from a stove ignited the benzine vapor and the resulting fire caused a loss of $5,000.

H-15672. A bar being drilled caught in some way, began to twist, and it became hot enough to ignite the cutting oil. The loss was $375.

H-19765. An empty metal drum that had contained creosote oil was placed accidentally with other drums for repairs without being cleaned. When the workman applied his torch to the drum an explosion occurred. The man was severely burned. The loss was small.

Grinding and Polishing.

Fire Causes.

Cause of Fire	No. of Fires
Sparks from emery wheel	22
Spontaneous ignition of emery dust	2
Spontaneous ignition of buffing dust	31
Sparks from buffing machines	28
Open flame ignited buffing dust	7
Friction at buffing machine	4
Miscellaneous	5
Total	99

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	69	18	87
Large Loss	3	9	12
Total	72	27	99

Interesting Causes of Grinding and Polishing Fires.

H-19081. A spark from an emery wheel set fire to a barrel of paint. An employee attempted to carry the barrel out of the building but spilled the paint, causing the fire to spread. The loss was $32,000.

S-27465. A spark caused by a piece of wire entangled in the blower fan caused an explosion of buffing dust. Six girls died from burns. The explosion damage was large.

Assembling Processes.

Fire Causes.

Cause of Fire	No. of Fires
WELDING	
Acetylene gas escaped from leak or break	18
Sparks from acetylene torch	14
Acetylene explosion	3
Wet carbide	1
Oxygen explosion	1
Sparks from electric welder	13
Hot metal	4
Fuel oil	3
Gas	1
	— 58

TINNING		
Tallow or grease ignited	17	
Heat from tinning furnace	14	
Oil in pots overheated	4	
Gasoline vapor ignited	1	
	—	36
SOLDERING		
Heat from soldering stove	16	
Gasoline in soldering torch ignited	9	
Hot soldering iron	2	
Miscellaneous	3	
	—	30
PLATING		
Asphaltum or pitch lining of tank ignited	7	
Flammable liquids	5	
Miscellaneous	5	
	—	17
METAL TREATING		
Case hardening	12	
Blueing	8	
Galvanizing	5	
Brazing	6	
Pickling	4	
Bronzing	2	
Carbonizing	2	
Rust-proofing	2	
Gun metal finish	2	
Niter finish	1	
	—	44
MISCELLANEOUS		
Wax melting	10	
Flammable liquids used for cleaning	8	
Spontaneous ignition of oily material	4	
Spark from machine	4	
Rosin ignited	3	
Miscellaneous	10	
	—	39
Total Number of Fires		224

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	167	35	202
Large Loss	6	10	16
No Data	..	6	6
Total	173	51	224

Interesting Causes of Assembling Process Fires.

H-16129. An employee was smoking while charging acetylene cylinders. When changing cylinders the gas ignited and an explosion occurred. The loss was $1300.

H-15919. An employee pulled the hose off a kerosene tank feeding a pre-heating torch at 20 pounds pressure. The kerosene blew over the room and the employee was badly burned. The loss was $1,375.

S-24997. Grease and dust in a metal vent from the canopy over a can soldering machine ignited from a gas flame heating solder. The loss was small.

H-9059. An employee was repairing a wooden electroplating tank and poured hot asphaltum in it to stop leaks. He used a blow torch to smooth down the asphaltum and it caught fire. The loss was $7,000.

Finishing Processes.

Fire Causes.

Cause of Fire	No. of Fires	
DIPPING		
Sparks or flame ignited dip	94	
Matches ignited dip	37	
Dip tank fire—exact cause unknown	33	
Hot metal ignited dip	10	
Explosion of dip	4	
Spontaneous ignition of varnish	13	
Steam pipe ignited dip	3	
Heat of sun ignited dip	1	
		195
BAKING AND DRYING		
Flammable vapors ignited	75	
Explosion of vapors	57	
Overheated ovens	104	
Drippings from freshly dipped parts ignited in oven	24	
Clogged vent flue from oven	10	
Short circuit or electric spark ignited vapors	10	
Short circuit in electric oven	7	
Started in oven, exact cause unknown	43	
		330
PAINT SPRAYING		
Electric spark ignited paint	22	
Spontaneous ignition in spray booth	10	
Started in spray booth from miscellaneous causes	11	
		43
PAINTING		
Spontaneous ignition of paint rags	27	
Open light ignited paint	14	
Match ignited paint	7	
Miscellaneous	5	
		53
Varnish kettle boiled over		7
Total Finishing Process Fires		628

Analysis of Loss.

	Sprinklered Fires	Unsprinklered Fires	Total No. of Fires
Small Loss	440	81	521
Large Loss	29	64	93
No Data	5	9	14
Total	474	154	628

Interesting Causes of Finishing Process Fires.

H-4674. A watchman carrying a kerosene lantern started to dip some shovels in an open tank containing varnish compound. An explosion occurred and the resulting fire caused a loss of $40,000.

S-26071. An employee dipping a fender in a naphtha bath hit it against an uninsulated electric wire causing an arc. The tank ignited but twenty sprinklers opened and controlled the fire with small loss.

S-34777. An employee claimed that the material in a dip tank was non-flammable and threw in a lighted match to prove it. The loss was $1,300.

S-23573. Sun shining through the window glass focussed on a lacquer dip tank, igniting the contents. A pail of water thrown on the tank spread the fire.

H-16443. Springs which had been dipped in japan and then in naphtha were placed in an oven which was too hot. An explosion of the fumes occurred. The loss was $18,000.

H-505. The electric lights in the plant were out of service and an employee used a lighted candle when putting some freshly dipped articles in an oven. The candle fell into the basket of articles and ignited the vapor. The loss was $45,000.

S-35691. An explosion occurred in a japan oven owing to the fact that work in process had been placed in the oven immediately after dipping, instead of being allowed to drain. The loss was $4,000.

S-22310. Fumes from a recently filled japanning oven were ignited in a common vent from the exhaust heat of an adjoining oven. The fire flashed back igniting fresh japan on the stock in the oven.

S-24590. A short circuit in one of the heating coils of an electric enamelling oven ignited the vapors in the oven. The fire spread rapidly. The loss was $84,000.

H-17778. A gas burning lacquer drying oven which had been in use during the day and in which the gas was not turned off at night overheated and ignited a frame partition nearby. The loss was $6,700.

S-36743. A spark from a motor located inside of the spray booth ignited lacquer fumes and caused a flash fire. Lacquer on the sides of the booth ignited and the fire spread to a dip tank. The loss was $3,000.

H-15600. The blowing of a fuse controlling a ventilating fan motor in the paint spraying section ignited the flammable vapors and the fire quickly spread along paint soaked walls. The loss was $106,000.

H-14438. An employee threw a piece of lighted waste at another employee, which, missing him, fell into a bucket of paint thinned with naphtha. The loss was $7,500.

Richmond, Indiana, High School Fire.

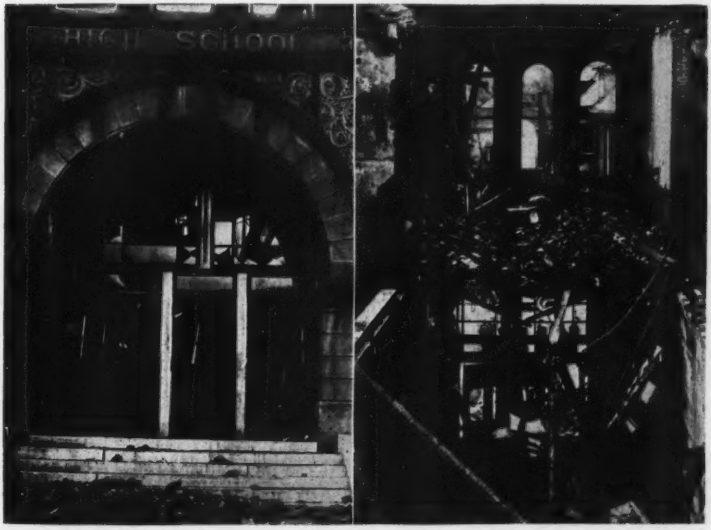
Report by Carl S. Steup.

(Member N. F. P. A.)

Fire in the Richmond, Indiana, High School on March 29, 1924, destroyed one section of the building and damaged another part with a loss estimated at $150,000. This fire is of interest not only because typical of fires in this class of structure, but because of the manner of spread of the fire from the basement to the upper floors through metal ventilating ducts and because of the illustration furnished by the fire of the value of cut-offs between sections of buildings and the saving of important records which were in fire-resisting safes.

Construction.

The building in which the fire started was called the "Garfield Annex." It was a two-story and basement structure of ordinary brick, joisted construction with a slate roof. This section was built in 1895. Adjoining



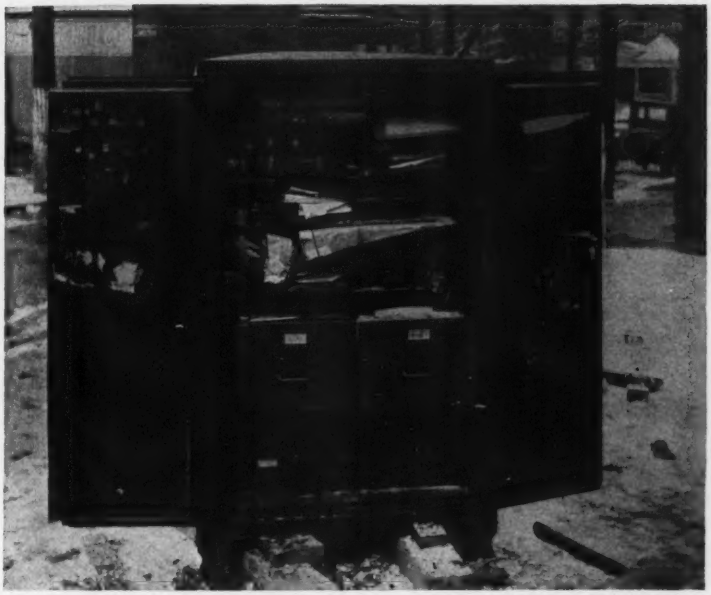
The Richmond, Indiana, High School fire. Left—front entrance of building indicating general appearance of exterior construction. Right—ruins of the annex. Fire started in basement but spread rapidly to the attic through ventilating ducts, the principal damage being to the upper parts of the building.

The safe, which formerly stood in the offices of the Board of Education on the second floor, as it lay in the ruins after falling to the basement. (See next illustration.)

it was the "Morton High School," a recently erected building of semi-fire resistive construction, three stories and basement. The openings between the main building and the annex were protected by labeled fire doors with wired glass panels. One of these doors was carried away during the collapse of part of the building, presumably indicating some fault in installation.

Story of the Fire.

The alarm of this fire was turned in at 3 A. M. It is reported that a passerby saw light in the basement of the building some two hours earlier and it is presumed that the fire actually started some hours before its discovery. The point of origin was the waste paper storage and baling room. The cause, although not definitely determined, is attributed to spontaneous ignition in these waste materials. The fire spread rapidly through the metal ventilating ducts and mushroomed through the attic. The fire department was seriously handicapped during the early stages of the fire because an electrical storm early the previous evening partially disabled the alarm system so that only the regular night force of the department could be summoned. Considerable delay was experienced before other men were notified.



The safe after it had been opened. As the picture shows, this safe protected its contents against fire damage. (See preceding illustration.)

After the fire had gained headway efforts of the department were confined to preventing the entrance of fire into the main section of the building. This effort was successful, except that when the roof collapsed the fire door on the second floor was carried away and fire entered the main section at this point. It was controlled, however, before doing serious damage to the main building. The fire was reported as being under control at 5 A. M. and out at 10 A. M.

This school is surrounded by a large district of shingle-roofed houses. During the fire a strong wind carried large embers to these roofs and were it not for opportune rain a considerable section of the city would have been endangered.

Record Protection.

The offices of the Board of Education were on the second floor of the burned section. Most of the records were in ordinary wooden filing cases and were completely destroyed. The financial records were kept in labeled fire-resisting safes. These fell from the second floor to the basement when the floor collapsed. The safes preserved their contents satisfactorily as the accompanying illustration shows.

Lessons of the Fire.

This fire shows the bad influence of metal ventilating ducts in spreading fire, especially those which are not cut off from the basement and terminate in an open attic space. Although the fire started in the basement more than half of that part of the building was untouched and a considerable part of the first floor was still intact after the fire, the damage being principally confined to the second floor and roof, which were completely destroyed.

The advantages of protecting openings between sections of a building were clearly shown, also the fact that protective devices may fail because of faulty installation.

The importance of proper record protection is clearly shown by this fire as the records which were in proper containers were preserved intact, while those in ordinary wooden filing cases were completely destroyed.

St. Paul Gasoline Fire.

Report by John Townsend, Jr.

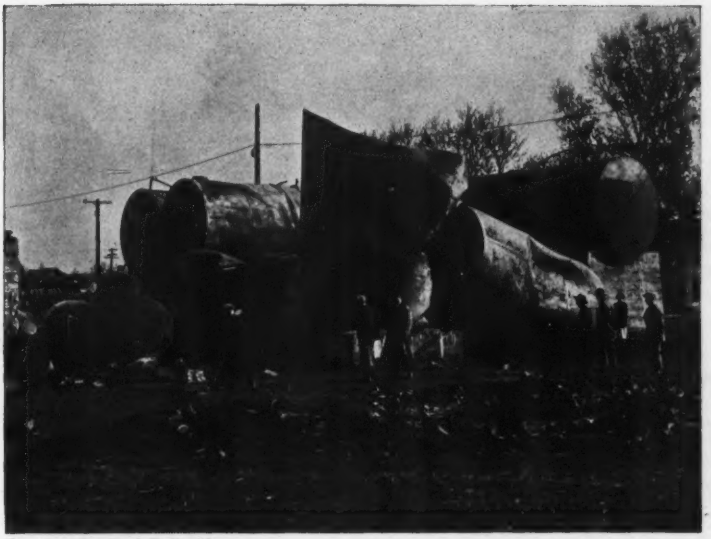
(Member N. F. P. A.)

A gasoline fire in the plant of the Craig Oil Refining Co., which started with an explosion of vapor from a tank car of casinghead gasoline at St. Paul on May 19, 1924, cost two lives, four injuries, and $90,000 damage (see frontispiece).

A state oil inspector and an employee of the Craig Oil Refining Co. were on top of a tank car removing the cover. They were unaware of the nature of the contents of the car, assuming that it contained ordinary gasoline or kerosene. It is stated that the car was not properly placarded and that the pressure gauge did not function.

As the cover was loosened the casinghead gasoline vapor, which had been under considerable pressure, blew off the cover. One of the two men jumped and the other was blown to the ground. These men escaped with minor injuries.

The vapor was ignited at the plant boiler stack fifty feet distant. The first of the three ensuing explosions ignited the oil soaked clothing of two oil company employees who were standing about fifty feet from the car. Their burning clothing was extinguished by other employees, but not before they had been fatally burned. A boy standing nearby was only slightly injured by the explosions. This is evidence that the death of the two men was not due directly to the explosion, but to the burning of their oil soaked clothing which was ignited by the explosion.



Courtesy St. Paul Daily News.

Ruins of the St. Paul gasoline fire showing damage to the tanks and the general congestion of the plant.

This oil plant had no fire protection of any kind, the oil tanks were close together and were not provided with dikes, and the buildings, while of non-combustible construction, were not cut off in any way from the oil storage area. As might have been expected the resulting fire completely destroyed the plant, as may be seen from the accompanying illustration. The fire department's efforts were confined to preventing the spread of the fire to surrounding property. Thirteen hose streams were used and after the fire was under control one engine company remained for a day and a half to prevent the burning gasoline from spreading. The exploding of gasoline drums which were blown high in the air and came down with terrific force seriously endangered the fire fighters, but except for the cutting of one hose line, no casualties resulted from this cause.

This fire would not have occurred if the vapor had been allowed to escape slowly from the tank car. If the boiler fire had not been near the place where the tank car was unloaded the vapor would not have been ignited at the boiler stack. If the storage tanks had been properly separated and diked the fire could have been controlled before the entire plant was destroyed.

Cuban Sugar Warehouse Fire.

Report by L. R. Cole.

A fire in the warehouse of the Cuba Cane Sugar Corporation at Puerto Tarafa, Cuba, on April 16, 1924, caused loss of more than $1,000,000 and is interesting because it shows conditions typical of unprotected sugar ports in Cuba.

Construction of Warehouse.

The building, 80 ft. wide by 500 ft. long, was of steel superstructure, heavy galvanized iron sides and roof, solid concrete foundations and floor. Electric wiring was all in metal conduits and an inspection of the other warehouses showed all wiring to be in good condition. The building was practically a total loss as is shown by the accompanying illustrations.

At the time of the fire the warehouse was full of sugar in bags ready for shipment.

Cause.

While the cause has not been definitely determined, it is believed that it may have been due to spontaneous ignition.

No work had been done in the warehouse for two days prior to the fire, and none in the section where the fire originated for two weeks. The building was tightly closed, with little ventilation and no provision for circulation of air. The floor and foundation were of solid concrete. The section of the building where the fire originated was exposed to the sun the greater part of the day. According to the testimony of those first reaching the fire, it started in the second tier of bags from the bottom. This tends to substantiate the theory of spontaneous ignition. If this were the case, the natural place for fire to start would be in the second or third layer of bags, due to the pressure of the twenty-five or twenty-eight bags piled on top. Fire would not originate in the bottom bag, because the heat from it would be absorbed by the concrete floor.

Story of the Fire.

The fire was discovered by the watchman (3 hour rounds) at 11:40 P. M. on April 16, 1924. He immediately gave the alarm by firing his revolver and the few inhabitants of the town were aroused. When the alarm was given, the captain of one of the company's vessels, in the harbor

This report was secured through the courtesy of Frank Trollope (Member N. F. P. A.) of the Asociacion Cubana de Compañias de Seguros Contra Incendio.

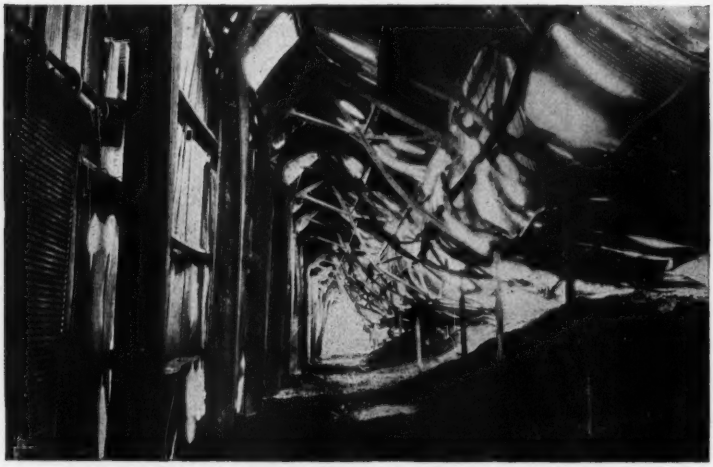
Exterior of the building after Sugar Warehouse fire showing the extent of the damage to corrugated iron and steel frame construction.

at the time, and two or three men broke into the warehouse through a small door at the end of the building where the fire started. No water or other fire fighting facilities were available until small hand extinguishers were brought from the ship. Two strings of loaded and empty cars were on tracks on either side of the warehouse, which had to be removed to prevent the fire spreading to other warehouses. About two hours later a donkey engine was put in operation, pumping water from the tender of a locomotive. This supply was soon exhausted.

At the beginning of the fire an attempt was made to remove sugar from the warehouse sufficiently to isolate the fire and work was started about 150 feet from the fire towards the center of the warehouse.

Tarafa has few inhabitants, the majority of the laborers residing in Nuevitas, about four kilometers distant. Owing to this a small number of men were available and after about 650 bags were removed, the workers were driven out by the fire, after which all efforts were directed to protect other warehouses.

The water used in Tarafa is brought in by the railroad in tank cars and emptied into tanks in the yards. The supply for the town is pumped from these tanks to an elevated tank on the hill, where the town is located. The capacity of this tank is 50,000 gallons. On the night of the fire this tank was dry, according to statements of guests of the hotel. A hose line was laid from the ship above referred to and sea water pumped by the ship's power. The following day, about 2 P. M., the fire department of Moron arrived by special train of the Cuba Northern, but by that



Interior view taken after Sugar Warehouse fire in Cuba. Note condition of the unprotected steel framework.

time the fire had gained such headway that little could be done except to confine the fire to the building and protect nearby warehouses.

Conclusion.

The building was practically a total loss, as may be seen from the accompanying illustrations. The contents were completely destroyed, except for the 652 bags of sugar removed early in the fire. The loss on the sugar alone was $1,150,000.

A similar fire could occur at this port, or at any other port where no protection is provided, at any time. In order to eliminate the probability of a re-occurrence of such fires, it will be necessary to provide an adequate system of mains and power for pumping the water from the sea. Such a system can be installed at Tarafa at a very nominal cost and had one been installed prior to this fire, the loss would not have exceeded a few thousand dollars.

Fires in Which There Was Loss of Life.

These notes are intended to point out typical conditions under which loss of life has occurred, that they may be known and guarded against.

Motion Picture Film.

H-20753. MANCHESTER, N. H., MAY 13, 1924. The film stopped in a motion picture machine in the booth of a theatre. It ignited from the heat of the light. Two men were in the booth at the time; one was killed and the other seriously injured. When the fire started, the operator of the machine, painfully burned, rushed out of the film booth alone, raced down the steps and told nearby spectators to save the other man. The man was stretched out unconscious on the floor of the booth when his rescuers reached the door. Two men tried to enter and drag the man out but flames drove them back; the man was finally dragged out with the aid of an umbrella handle. He was burned in practically every part of his body and died the next morning in the hospital. The fire did only slight damage to the building and although there was a slight confusion among the people in the balcony, the audience on the main floor walked out quietly.

Inadequate Exits.

H-20659. GRAND RAPIDS, MICH., APRIL 1, 1924. Six persons were killed and several seriously injured in attempting to escape from a fire which started in the basement of an old hotel and spread rapidly to the sixth floor through the freight elevator shaft. When the fire was discovered an attempt was made to warn the occupants of the building by the electric fire alarm, but this was found to be out of service. The origin of the fire has not definitely been determined but it is believed to have started in sweepings, in which there were cigar and cigarette stubs. This refuse was placed near the freight elevator where there was a quantity of rubbish.

The loss of life occurred because the guests could not escape from the upper floors. On the roof of a lower adjoining building were heard shouts of some of the guests who had jumped from one to three stories. Two women were found lying on the roof and both were lowered through the skylight, one dying later in the hospital. With burning embers falling heavily, an unconscious man was discovered in the light well between the adjoining building and the hotel. He was rushed to the hospital where he died. One man was last seen in the hallway near his room on the sixth floor.

One woman who saved her life by sliding hand over hand down a rope secured to the roof by firemen reported that her friend was at her side when they were groping through the smoke and that her last recollection concerning her was that she fainted at her side. Her body was later discovered among the unidentified ones.

The inevitable panic seized three and they were killed by jumping. Two were apparently overcome by smoke and fell back into the flames. One fireman is reported to have been killed fighting the blaze.

The building was a total loss and the contents badly damaged.

Trapped While Attempting to Extinguish Fire.

H-20694. NEW YORK CITY, APRIL 23, 1924. A fire, which started in the rigger's room on the first floor of a pier is thought to have been caused by careless smoking. Three of the employees stretched a line of hose from the standpipe to the point of origin of the fire. The superintendent went to turn in a fire alarm. He was unable to return to the seat of the fire due to the dense smoke. The rigger's foreman and helper were trapped at end of the pier while fighting the fire and their escape was cut off. The foreman's charred body was found in the rigger's room after the fire and the helper was removed to the hospital in a critical condition.

Radio Equipment.

H-20688. MONTCLAIR, N. J., APRIL 19, 1924. For nearly a year an abandoned radio aerial had been hanging with one end loose and the other attached to the top of pole carrying 2400-volt electric light wires. On the morning of April 19, the dangling aerial came in contact with the high-tension wires strung below it and when its lower end touched a wire fence surrounding a vacant lot, sparks set a hedge and underbrush on fire. A milkman who touched the wire was knocked unconscious to the sidewalk, and when the fire department responded, two firemen who endeavored to cut the wire were instantly killed. While one of these firemen was attempting to cut the aerial away from the fence and so break the circuit, the wind blew the charged aerial against his face and he was instantly killed. The other fireman rushed to his aid and attempted to pull him away from the wire. As he did so, the wire swung toward him and he raised his arm to ward it off. The wire struck him and he was hurled to the ground dead. The chief of the fire department arrived at this time and without waiting to don the rubber gloves he seized a pair of pliers and hacked at the wire finally snapping it and thus breaking the circuit. It was probably only the fact that the wire was then grounded through the bodies of the other men that saved him from death.

H-20675. PEABODY, MASS., APRIL 9, 1924. The accident which caused the death of Mrs. Wilson was unusual. In the basement of the house is a work bench where radio and other electrical work is done. A connection had been left between a storage battery and the city electric current so that the battery could be charged. The city supplies an alternating electric current and to transform that into a direct current for charging the battery, the current had to pass through a rectifier, a small box with an electric lamp in it. The box was on the floor at the end of a work bench, and was usually covered with a metal case with perforations to allow ventilation. This case was not in place at the time. Mrs. Wilson went into the basement and stood sifting ashes, in such a position that her dress hung over the rectifier on the floor behind her. The heat from the light in the rectifier, when her dress shut off the air, set fire to her dress. She ran out of doors into the yard and several men succeeded in smothering the fire by coats and other clothing, but not before she was fatally burned.